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Efficiency and productivity convergence in health care systems: Evidence from EU member countries*

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Abstract

This paper investigates whether there has been a convergence in technical efficiency and productivity levels of the health care systems of twenty-six EU members and a candidate country over the period 1995-2012. The results of convergence analysis suggest that both β (beta)-convergence and σ (sigma)-convergence in technical efficiency and productivity have occurred among sampled countries. Furthermore, the findings reveal that the dispersion of technical efficiency and productivity scores among sampled countries declined over the sample period. Overall, these results provide evidence in favor of the process of health care systems integration in the EU.

Key words: Technical efficiency, productivity, convergence, health care systems.

JEL codes: I10, I11, I18.

1. Introduction

Health expenditures have started to increase in all EU countries during the second half of the 20th century and continued growing in the first decade of the 21st

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century. They amounted on average to 7.44% of GDP in 1995 and to 9.7% of GDP in 2014 in the EU15[1]. Despite the rapid developments in medical science, technology, and treatment techniques, rapidly rising health care spending in Europe raises concerns about the financial and organizational efficiency of health care systems. Moreover, significant differences in health care resources among old and new members of the EU are observed in addition to economic and legal differences[2]. These differences create great challenges in terms of efficiency disparities between old and new EU member countries. It is important for policy makers knowing whether these disparities have diminished over time. In addition, the coordination of health policies in the European Union is in progress. The EU Health Strategy "Together for Health" adopted in 2007 is the most important step in this regard. Hence, this paper tests this strategy indirectly by investigating convergence in technical efficiency and productivity for the health care systems in the EU.

Two major concepts of convergence, β (beta)-convergence and σ (sigma)-convergence, are used to test the convergence in technical efficiency and productivity measures. This study differs from the previous studies since it analyzes the convergence in efficiency and productivity among health care systems of the EU member countries. Most of the previous research in the related literature has focused only on the efficiency of European health care sectors. This study, however, focuses on the converging patterns of EU health systems in terms of both efficiency and productivity. The focus on convergence is also crucial given that it touches on important questions such as whether inefficient or less efficient member countries can eventually catch up to efficiency levels of the best-performing EU countries over time.

This paper includes both old and new EU member countries, and a candidate country (Turkey) into the analysis to examine whether a catching-up process has taken place in the health markets of all EU member countries. Including all member countries in the analysis is essential since there is significant variation in the efficiency levels of the old and new EU member countries. Structural differences could cause an efficiency gap between old and new EU member countries. Hence, one of the aims of this paper is to investigate whether this gap has decreased over the sample period 1995–2012. It is also important to investigate the adjustment of the performance of health care systems in the new member countries to those of the old EU members.

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[1] See Health resources - Health spending - OECD Data: https://data.oecd.org/healthres/health-spending.htm.

[2] It should be noted that the rate of increase in health care resources is higher in the new member countries than the older ones.

This study also investigates the evolution of technical efficiency and total factor productivity scores in the sampled countries over time. It examines whether there has been an overall improvement in productivity both in the EU members and in the candidate country. There were numerous studies investigating the performance of health care systems in European countries, but this paper is more comprehensive than previous studies since it includes most of the EU members and a candidate country in the efficiency and productivity analysis, and uses a common frontier with country-specific health care outcomes to generate efficiency scores. Overall, empirical findings obtained from the study may provide guidance both to the institutions that regulate the health care sectors and to policy makers in the EU. This study will also contribute to the related literature significantly since it includes a group of countries whose economic and political integration are almost completed.

The remainder of the paper is organized as follows: Section 2 provides a brief review of the related literature. Section 3 discusses the methodology and the econometric specification. The data and empirical results of the estimations are reported in section 4. The paper's concluding remarks are provided in section 5.

2. Literature review

There is a large applied literature on the measurement of technical efficiency of health care systems. The analysis of efficiency was first introduced into the economic literature by the works of Debreu (1951), Koopmans (1951), and Farrell (1957). Thereafter, there has been a large number and comprehensive papers dedicated to the measurement of efficiency for various decision-making units.

A large body of paper has examined the efficiency of health care systems in the related literature. However, the number of studies measuring the efficiency of European health care systems in the cross-country context is relatively limited. For instance, Asandului et al. (2014) measure the efficiency of public health care systems for 30 European countries by applying input-oriented data envelopment analysis (DEA) method for the year 2010. Three output variables such as life expectancy at birth, health-adjusted life expectancy, and infant mortality rate are used in the study. Their findings show that most of the countries in the sample is inefficient. Medeiros and Schwierz (2015) estimate relative efficiency of the health care systems across all EU countries by applying DEA method. They use life expectancy, healthy life expectancy, and amenable mortality rates as outputs. The results of their study show that the Czech Republic, Lithuania, and Slovakia have the lowest efficiency scores, while Belgium, Cyprus, Spain, France, Luxembourg, Sweden, and the Netherlands are among the best performers. Moreover, their results reveal that, on average, life expectancy at birth could be increased by 2.3%, healthy life expectancy could be increased by 6.1 years, and average amenable mortality rates could be nearly halved in the EU. Aristovnik (2015) analyzes the regional performance of health care systems within the EU at the NUTS 2 level over the period 2007-2012. Output-oriented DEA method is used in this study to estimate the relative efficiency of 151 regions in the old EU member states (EU-15) and 54 regions in the new EU member states (EU-13). The results of the study show that efficiency scores differ significantly across the selected regions. Furthermore, the findings of the study reveal that less developed regions are more efficient than developed regions because developed regions generally serve as national medical centers employing large amounts of health resources.

The issue of convergence has also been widely investigated in the related literature. However, the convergence literature generally tests for the convergence in real income per capita among countries. There are only a few papers focus on the convergence of health care systems. Some prior studies using data from EU countries have investigated the convergence in both health expenditures and health outcomes. For instance, Nixon (2000) examines both σ- and β-convergence in health expenditures and in health outcomes as represented by life expectancy and infant mortality rates. In the study, σ-convergence is examined for 15 EU countries between 1960 and 1995, and β-convergence for the same countries is analyzed over the years 1980-1995. The results of the study show that there are statistically significant σ-convergence and β-convergence in both health care expenditures and health outcomes. Hitiris and Nixon (2001) examine the σ- and β- convergence both in per capita health care spending and in the share of health expenditure in national income for 15 EU member countries over the period 1980-1995. Their results show that there are both strong absolute and conditional convergence in health care expenditure per head across all the EU countries over the sample period. Further, their findings provide the evidence of strong absolute convergence in the share of health expenditure in national income across 15 EU countries, but conditional convergence is rejected. Happich and von Lengerke (2007) analyze convergence in life expectancy for the 15 EU member-states over the years 1980 to 1989 and 1989 to 1998. A Markov approach is applied to the data to classify member states. They find the evidence of slow convergence in the 1980s, while convergence is close to non-existent in the 1990s.

Kerem et al. (2008) analyze the β, σ, and γ-convergence in health care expenditures for 23 EU countries using cross-sectional data for the period 1992-2004. Their results show that there are β-convergence and σ-convergence for all 23 EU countries during the sample period, but a weak evidence of γ-convergence measured by the Kendall's rank concordance index is found for sample countries. Montanari and Nelson (2013) analyze the development in three health care dimensions of 19 EU countries over the period 1980-2006. These three health care dimensions include coverage, financing of public and private health care expenditures, and health care provision. Their results show that there is convergence only in private health care financing, while other dimensions such as health care provision has tended to diverge.

The review of the related literature shows that existing studies generally focus only on the efficiency measurement of the health care sectors. The issue of convergence has been examined only under the context of health expenditures and health outcomes. In this manner, the main contribution of this study to the related literature is to analyze the convergence in efficiency among member countries in the EU. Furthermore, test for convergence of total factor productivity will also provide some insight as to the spread, adoption, and convergence of technical advances for the EU framework.

3. Methodology

The basic idea of efficiency analysis is to make a comparison among a group of decision-making units (DMUs) in order to evaluate how resources (inputs) are used to produce goods or services (outputs)[3]. Following a number of studies on the performance of the health care industry, this paper uses the mathematical programming technique called data envelopment analysis, which was first developed by Charnes et al. (1978) and later improved by Banker et al. (1984). In contrast to parametric approaches, the DEA approach does not need the specification of a functional form for the frontier (inputs-outputs relation) and a distributional form for the inefficiency and error terms. Hence, DEA assumes that there are no random fluctuations in production and any departure from the frontier is considered as inefficiency. DEA can be used to compute technical and scale efficiency without requiring information on input and output prices. Moreover, since it is relatively less data demanding, it works well with a small sample size.

3.1.Measuring technical efficiency

Technical efficiency can be measured based on either an input orientation or output orientation in the context of the DEA approach. The input-oriented approach aims at reducing the input amount by as much as possible while keeping at least the present output level. Hence, the output level remains unchanged and input levels are reduced proportionately until the frontier is reached. The output-oriented approach, however, holds the input bundle fixed and expands the output level until the frontier is reached. These two orientations yield equal values under the constant returns to scale (CRS), but not when the variable returns to scale (VRS) is assumed.

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3 In our case, the DMU represents a country.

The input-oriented specification in comparison to the output-oriented allows us to identify the sources of input waste in the country and draw some policy conclusions. This is a framework generally adopted when the decision-making unit can control the inputs but has no control over the outputs (Daraio and Simar, 2007). Hence, in this study input-oriented specification of DEA is used to measure efficiency[4]. To compute technical efficiency of country *i*, following linear programming model is used for each country in the sample:

$$\min_{\theta,\lambda} \theta_i \tag{1}$$

Subject to

$$\theta_i X_{ki} \geq \sum_j \lambda_j X_{kj} \qquad k = 1, 2, \ldots\ldots K,$$
$$Y_{mi} \leq \sum_j \lambda_j Y_{mj} \qquad m = 1, 2, \ldots\ldots M,$$
$$\lambda_j \geq 0 \qquad j = 1, 2, \ldots\ldots N$$

where X and Y represent the vector of inputs and outputs, respectively, and λ_j defines the weight of each country within the reference or peer group. Hence, the solution, θ_i^*, is the measure of the technical efficiency of country *i*. Country *i* is technically efficient if $\theta_i^* = 1$, and it is technically inefficient if $\theta_i^* < 1$[5]. Three different technologies could be assumed by imposing additional restrictions to above problem. The constant returns to scale technology does not require further restriction on λ. In case of the variable returns to scale and non-increasing returns to scale (NIRS) technologies, the restrictions are $\sum_j \lambda_j = 1$ and $\sum_j \lambda_j \leq 1$, respectively.

3.2. Measuring productivity

The total factor productivity (TFP) measures change in output relative to inputs. The Malmquist index approach, which is the most commonly used measure of productivity change in the literature, is employed to measure TFP change in this

[4] We also used output-oriented specification for robustness test. The results are very similar. They are not reported for the sake of the flow of the paper. However, they are available from the authors upon request.

[5] For example, $\theta_i^* = 0.90$ suggests that country i should be able to use only 90% of its current level of inputs and still should be able to produce the same amount of output. Hence, this would allow a 10% reduction in inputs.

paper. This index measures TFP change between two data points by computing the ratio of the distance of each data point relative to a common technology. The main advantage of the Malmquist index is that it does not make assumptions about the optimizing behavior of the producers and it allows for inefficiency (Färe et al., 1994).

To avoid an arbitrary choice of reference technology, the input-oriented Malmquist TFP index is defined as the geometric mean of M (see Färe et al., 1994):

$$M(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D^t(x^t, y^t)}{D^t(x^{t+1}, y^{t+1})} \times \frac{D^{t+1}(x^t, y^t)}{D^{t+1}(x^{t+1}, y^{t+1})} \right]^{0.5} \tag{2}$$

where $M(\cdot)$ indicates the Malmquist TFP index and $D(\cdot)$ represents the distance from the period t observation to the period $t+1$ technology. A value of $M(\cdot)$ greater than one indicates a positive TFP growth between periods t and $t+1$, while a value less than one indicates a TFP decline. In addition, a value equal to 1 indicates no change in TFP.

A useful feature of the Malmquist index is that it enables us to decompose the change in TFP into technical change (a shift of the production frontier) and efficiency change (movement towards the production frontier) components. Following Färe et al. (1994), this decomposition is defined as:

$$M\ (x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D^t(x^t, y^t)}{D^{t+1}(x^{t+1}, y^{t+1})} \left[\frac{D^{t+1}(x^t, y^t)}{D^t(x^t, y^t)} \times \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^{t+1}, y^{t+1})} \right]^{0.5} \tag{3}$$

where the ratio outside the brackets measures the change in technical efficiency (TE), which measures the change in the efficiency of a country relative to the best practice frontier. The term in the bracket is a measure of the technical change (TC). It reflects the improvement or deterioration of best practice country. The main idea for the decomposition is that it provides information on the sources of the TFP change.

As indicated above, there are only two sources of productivity growth in the case of CRS technology. However, if the production technology exhibits the VRS, there are two additional sources of productivity growth: pure technical efficiency change and scale efficiency change. Hence, the efficiency change shown in Eq. (3) can be decomposed into pure efficiency change (PE) and scale efficiency (SE) change. Hence, the Malmquist TFP index can be shown as follows:

$$M\ (x^{t+1}, y^{t+1}, x^{t}, y^{t}) = PE * SE * TC \tag{4}$$

3.3. *β - Convergence and σ – Convergence*

One of the main objectives of this paper is to analyze the convergence in efficiency (or total factor productivity) among countries in the EU. The issue of convergence has been widely investigated in the related literature. Hence, the literature on convergence is well established. Barro and Sala-i-Martin (1991) proposed two concepts of convergence: β (beta)-convergence and σ (sigma)-convergence. β - convergence implies that countries with a low initial level grow faster than countries with a high initial level in the long run and both groups of countries will converge to the same steady state. Hence, β - convergence exists if the growth rate is negatively correlated with the initial level. The test of β -convergence is performed using the following equation:

$$\ln(Y_{it}) - \ln(Y_{i,t-1}) = \alpha + \beta \ln(Y_{i,t-1}) + \sum \delta_i Dum_i + \varepsilon_{it} \tag{5}$$

where Y_{it} denotes the mean technical efficiency (or total factor productivity) score of country *i* in year *t*, and Dum_i represents the country dummies, which incorporate fixed effects for countries in the equation in order to disentangle the country effects. α , β , and δ are the parameters to be estimated, and ε_{it} has zero mean, finite variance and is independent over *t* and *i*. Hence, there is β - convergence if the β coefficient of the initial level is negative.

The limits of β -convergence test have been discussed in Quah (1996). For instance, this test does not provide information on the evolution of the dispersion of the cross-sections. Hence, it would be valuable to measure the cross-sectional dispersion of the level of any variable over time. This is known as the σ -convergence. This type of convergence might be presented in terms of the standard deviation of levels across countries. There is convergence if the dispersion diminishes over time. Hence, if the standard deviation declines over time there is evidence of σ - convergence. β - convergence is a necessary but not a sufficient condition for σ - convergence since a shock can temporarily increase the dispersion in variable across countries, even when countries are converging to a steady state (Quah, 1996). The test of σ -convergence is performed using the following equation:

$$\Delta D_{it} = \alpha + \beta D_{i,t-1} + \sum \delta_i Dum_i + \varepsilon_{it} \quad (6)$$

where $D = (\ln Y_{it}) - (\overline{\ln Y_{it}})$ and $\Delta D = D_{it} - D_{i,t-1}$. Here, $\ln(Y_{it})$ denotes the natural logarithm of the mean technical efficiency (or total factor productivity) level of country *i* in year *t*, and $(\overline{\ln Y_{it}})$ denotes the mean of $\ln(Y_{it})$ for each period. There is σ - convergence if the β coefficient of the initial level is negative.

4. Data and empirical results

4.1. Data

Country level data were obtained from the World Health Organization, OECD Health Statistics, and the World Bank. We compare 26 member-countries and a candidate (Turkey) country. Two member countries, Cyprus and Romania, were dropped from the sample due to missing data values. The sample covers the period from 1995 to 2012. It should be noted that sampled countries were not uniform in reporting variables in each survey year. Hence, following Retzlaff-Roberts et al. (2004), slightly old values were used for some countries for some variables. This adjustment is unavoidable for our data sources and it is a common practice for the studies that used similar data sources. Basically, there are two approaches in the literature to handle this problem. First, as in Anderson et al. (2000), a value from a slightly earlier year could be used. Second, as in Färe et al. (1997), and Grubaugh and Santerre (1994), a smaller subset of countries could be used. Following Retzlaff-Roberts et al. (2004), we prefer to use the first approach in order to investigate technical efficiency and productivity for as many EU member countries as possible.

Table 1
Descriptive Statistics for Outputs and Inputs

	Outputs	**Inputs**			
Countries	Life expectancy (years from birth)	Infant mortality (deaths per 1,000 live births)	Health care expenditures (% of GDP)	Beds (per 1,000 population)	Physicians (per 1,000 population)
Old Members					
Austria	78.958 (1.348)	4.278 (0.658)	10.394 (0.625)	8.279 (0.663)	3.674 (0.759)
Belgium	78.682 (1.224)	4.467 (0.819)	9.189 (1.143)	6.991 (0.466)	3.655 (0.433)
Denmark	77.460 (1.408)	4.167 (0.706)	9.577 (1.093)	3.947 (0.533)	3.058 (0.341)
Finland	78.475 (1.314)	3.206 (0.593)	8.143 (0.626)	7.155 (1.074)	2.759 (0.357)
France	79.955 (1.490)	4.094 (0.579)	10.811 (0.585)	7.618 (0.807)	3.353 (0.123)
Germany	78.651 (1.314)	4.122 (0.588)	10.734 (0.465)	8.755 (0.529)	3.409 (0.247)
Greece	79.002 (1.056)	5.822 (1.807)	9.055 (0.633)	4.784 (0.071)	4.971 (0.862)
Ireland	78.230 (1.907)	4.856 (1.119)	7.471 (1.195)	4.612 (0.841)	2.606 (0.397)
Italy	80.533 (1.451)	4.294 (0.992)	8.316 (0.768)	4.475 (0.979)	4.014 (0.256)
Luxembourg	78.750 (1.614)	3.211 (1.122)	6.996 (0.961)	6.048 (0.597)	2.612 (0.196)
Netherlands	79.076 (1.314)	4.606 (0.692)	9.845 (1.645)	4.792 (0.287)	3.153 (0.382)
Portugal	77.482 (1.639)	4.628 (1.504)	9.347 (1.119)	3.643 (0.227)	3.388 (0.347)
Spain	80.027 (1.419)	5.011 (0.929)	8.179 (0.911)	3.646 (0.468)	3.310 (0.441)
Sweden	80.287 (0.970)	3.089 (0.499)	8.878 (0.615)	3.356 (0.772)	3.360 (0.363)
The U.K.	78.724 (1.404)	5.172 (0.611)	7.994 (1.121)	3.854 (0.618)	2.262 (0.330)
Overall Mean	***78.953 (0.920)***	***4.335 (0.758)***	***8.995 (1.156)***	***5.464 (1.842)***	***3.306 (0.655)***
New members and a candidate					
Bulgaria	72.272 (1.127)	15.128 (3.353)	6.660 (0.973)	7.458 (1.559)	3.556 (0.139)
Croatia	74.618 (1.713)	6.267 (1.443)	7.044 (0.562)	5.764 (0.262)	2.479 (0.233)
Czech Republic	75.703 (1.471)	5.072 (1.659)	6.850 (0.492)	7.939 (0.728)	3.415 (0.254)
Estonia	71.997 (2.545)	7.094 (3.130)	5.621 (0.635)	6.363 (1.048)	3.293 (0.307)
Hungary	72.416 (1.595)	8.194 (2.236)	7.658 (0.502)	7.767 (0.558)	3.078 (0.159)
Latvia	71.010 (1.927)	12.550 (3.994)	6.325 (0.336)	8.021 (1.576)	3.010 (0.096)
Lithuania	71.717 (1.196)	8.467 (2.425)	6.280 (0.537)	8.656 (1.438)	3.948 (0.182)
Malta	78.969 (1.330)	6.422 (0.905)	7.692 (1.187)	5.687 (1.166)	2.999 (0.431)
Poland	74.507 (1.487)	7.417 (2.333)	6.228 (0.522)	5.777 (0.689)	2.235 (0.136)
Slovakia	73.878 (1.140)	9.056 (1.945)	6.857 (1.221)	7.214 (0.774)	3.071 (0.255)
Slovenia	76.983 (2.033)	3.950 (1.154)	8.301 (0.490)	5.061 (0.437)	2.308 (0.150)
Turkey	71.424 (2.483)	28.894 (8.241)	5.295 (1.015)	2.572 (0.091)	1.387 (0.199)
Overall Mean	***73.791 (2.466)***	***9.876 (6.734)***	***6.734 (0.868)***	***6.523 (1.687)***	***2.898 (0.693)***

Notes: The figures in the parentheses are standard deviations. Data sources: The World Health Organization, OECD Health Statistics, and the World Bank.

Table 1 reports the mean values and standard deviations of outputs and inputs for the sampled countries. Following previous studies in the related literature, two outputs (life expectancy at birth and infant mortality) and three inputs (health care expenditures, beds per 1,000 population, and physicians per 1,000 population) are specified[6]. Each of the two outputs will be examined separately in order to assess whether there are differences in the efficiency and productivity levels. Hence, in the efficiency and productivity analyses, one output and three inputs will be used. The main idea behind choosing these outputs is that although the two groups of EU member countries have achieved a high life expectancy rates in the last two decades, they have not displayed similar success on infant mortality rates. Moreover, as indicated in Retzlaff-Roberts et al. (2004), these two outputs are less correlated compared to other alternative measures of population health status.

As mentioned before, one of the main objectives of this paper is to investigate the convergence in efficiency and productivity. Particularly, we investigate the convergence in efficiency and productivity among two groups of member countries. As seen in Table 1, the average life expectancy at birth in the old member countries is higher than that of in the new member countries. The average infant mortality rate, however, in the old member countries is less than that of in the new member countries. Similar analyses could be done for the input figures.

4.2. Empirical results

Table 2 reports mean technical efficiency scores and total factor productivity levels for each sampled country[7]. The second and third columns of Table 2 report technical efficiency scores with respect to life expectancy and infant mortality cases, respectively. In the case of life expectancy, the overall mean technical efficiency for the old (new) EU member countries is equal to 0.867 (0.846)[8]. This implies that sample countries could save about 13.3% (15.4%) of inputs if they use the best practice technology. The old members, on average, are slightly more efficient than the new members. The mean technical efficiency score also differs greatly across countries. The results suggest that the health care systems in Bulgaria, Malta, Spain, Sweden, Turkey, and the UK are fully efficient during the sample period. New members such as Bulgaria and Malta, and also the candidate country Turkey, are among the best performers since they produce the same output by using

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6 These inputs are under the control of health care systems.

7 The efficiency scores in Table 2 are based on VRS technology and input orientation is used in their calculations. In addition, the DEAP 2.1 developed by Tim Coelli was used to calculate technical efficiency and total productivity index in the paper. Interested readers can refer to Coelli (1996) and Coelli et al. (1998) for the technical details of the program and the comprehensive descriptions of the DEA models used in this paper.

8 It should be noted that the new member countries also include a candidate country, Turkey.

inputs in a most efficient way within the sample group used in the analysis. Austria, Belgium, and Germany, however, have the most inefficient health care systems among the old members. As for the infant mortality case, the results suggest the presence of inefficiency in most health care systems. The mean technical efficiency value of the old (new) members indicates that countries produce with an input inefficiency of 17.3% (9.4%). Hence, the result shows that the new member countries are more efficient than the old member countries. In addition, the mean technical efficiency score also differs greatly across countries when infant mortality is considered as the output. Bulgaria, Poland, Slovenia, Turkey, Portugal, and Sweden have fully efficient health care systems during the sample period. Austria, Belgium, Germany, and France, however, have the most inefficient systems.

Table 2 also shows that 3 of 27 countries are fully efficient for both outputs. These countries are Bulgaria, Sweden, and Turkey. That is, these countries are using their inputs efficiently to produce their current levels of both outputs (life expectancy and infant mortality). In addition, six of sampled countries (Malta, Poland, Portugal, Slovenia, Spain, and the UK) are fully efficient for one output, but inefficient for the other. Poland, Portugal, and Slovenia are efficient for the infant mortality case and inefficient for the life expectancy case. Hence, these member countries could produce higher levels of life expectancy given their level of inputs. However, Malta, Spain, and the UK are fully efficient in the case of life expectancy and inefficient in the case of infant mortality. They could improve their infant mortality by 23.7%, 6.8%, and 3.8%, respectively with the same level of inputs.

Table 2
Efficiency and Total Factor Productivity Scores by Countries

Countries	VRS-LE	VRS-MR	TFP-LE	TFP-MR
Old members				
Austria	0.682	0.610	1.017	0.949
Belgium	0.692	0.629	1.000	0.942
Denmark	0.824	0.873	1.017	0.979
Finland	0.836	0.955	1.003	0.978
France	0.884	0.662	0.992	0.998
Germany	0.687	0.644	1.294	1.133
Greece	0.868	0.725	1.340	1.138
Ireland	0.885	0.862	1.322	1.133
Italy	0.998	0.828	1.313	1.138
Luxembourg	0.885	0.975	1.215	1.138
Netherlands	0.835	0.752	1.287	1.154
Portugal	0.929	1.000	1.257	1.152
Spain	1.000	0.932	1.170	1.128
Sweden	**1.000**	**1.000**	1.184	1.126
United Kingdom	1.000	0.962	1.192	1.179
Overall	***0.867***	***0.827***	***1.174***	***1.084***
New members and a candidate				
Bulgaria	**1.000**	**1.000**	1.009	0.935
Croatia	0.908	0.961	1.005	0.954
Czech Republic	0.838	0.952	1.012	0.974
Estonia	0.683	0.977	1.011	0.986
Hungary	0.565	0.711	1.320	1.137
Latvia	0.709	0.824	1.318	1.161
Lithuania	0.692	0.908	1.257	1.144
Malta	1.000	0.763	1.183	1.157
Poland	0.999	1.000	1.286	1.158
Slovak Republic	0.792	0.776	1.219	1.143
Slovenia	0.964	1.000	1.183	1.144
Turkey	**1.000**	**1.000**	1.179	1.139
Overall	***0.846***	***0.906***	***1.165***	***1.086***

Notes: VRS-LE and VRS-MR denote technical efficiency scores with respect to life expectancy and infant mortality, respectively. VRS stands for the variable returns to scale technology. TFP-LE and TFP-MR, on the other hand, denote total factor productivity with respect to life expectancy and infant mortality, respectively.

Table 3
Efficiency Scores by Years

	Old members		***New members and a candidate***	
Year	VRS-LE	VRS-MR	VRS-LE	VRS-MR
1995	0.827	0.837	0.846	0.936
1996	0.832	0.830	0.850	0.938
1997	0.898	0.849	0.873	0.931
1998	0.847	0.831	0.854	0.937
1999	0.851	0.829	0.866	0.924
2000	0.850	0.853	0.865	0.923
2001	0.853	0.846	0.863	0.929
2002	0.876	0.847	0.858	0.927
2003	0.847	0.836	0.837	0.925
2004	0.860	0.810	0.822	0.888
2005	0.874	0.821	0.828	0.882
2006	0.873	0.813	0.828	0.864
2007	0.859	0.790	0.817	0.876
2008	0.898	0.817	0.799	0.891
2009	0.875	0.807	0.821	0.886
2010	0.883	0.812	0.859	0.888
2011	0.909	0.831	0.865	0.879
2012	0.898	0.832	0.875	0.886
Overall	***0.867***	***0.827***	***0.846***	***0.906***

Notes: VRS-LE and VRS-MR denote technical efficiency scores with respect to life expectancy and infant mortality, respectively. VRS stands for the variable returns to scale technology.

The entries in fourth and fifth columns of Table 2 report the annual geometric means of each country. The results indicate that all health care systems both in the old and in the new EU member countries seem to have experienced a significant productivity growth over the sample period with respect to both life expectancy and infant mortality. In the case of life expectancy, Greece (34%), Hungary (32%), Ireland (%32), and Latvia (31.8%) have the most productive health care systems. Productivity growth has been relatively modest for Austria, Belgium, Bulgaria, Croatia, the Czech Republic, Denmark, Estonia, and Finland. As for the other sampled countries, the productivity growth has been moderate[9]. In the infant

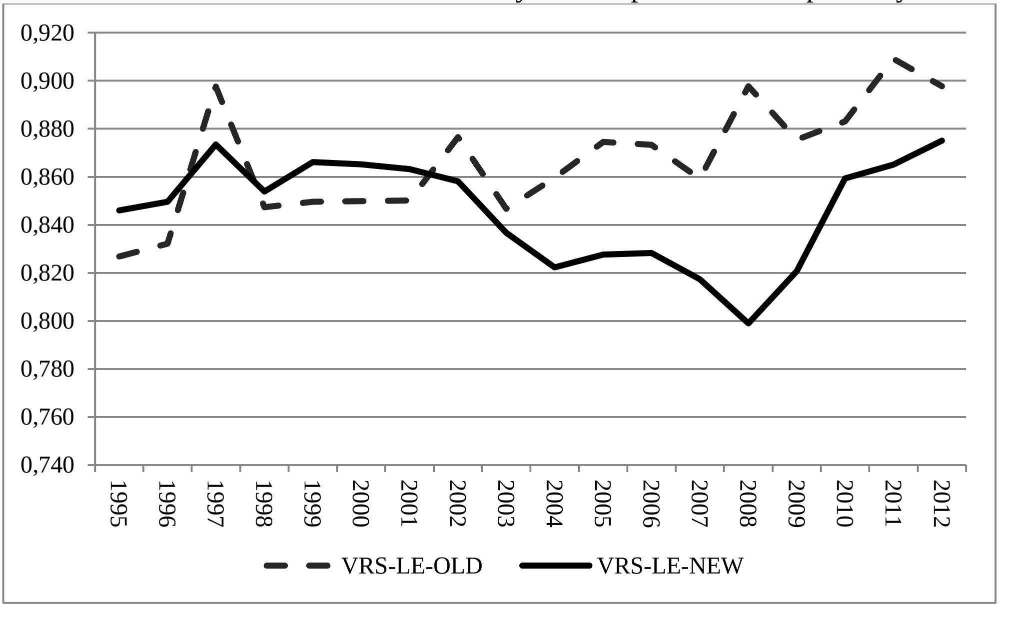
[9] According to the analysis of the decomposition of the Malmquist TFP, productivity growth in the sampled countries' health care systems has been brought mainly by a positive technical change. In

mortality case, the United Kingdom (17.9%) and Latvia (16.1%) have the most productive health care systems. Nearly one-third of countries have a productivity decline (Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, and France).

Table 3 reports the mean technical efficiency levels across time. The results indicate that mean technical efficiency levels do not fluctuate greatly along the eighteen years of our sample. In the case of old member countries, the mean efficiency level reaches the minimum in 1995 (0.827) and the maximum in 2011 (0.909) when life expectancy is considered as the output, and it reaches the minimum in 2007 (0.790) and the maximum in 2000 (0.853) when infant mortality is considered as the output. As for the new member countries, there is no clear trend. The mean efficiency level reaches the minimum in 2008 (0.799) and the maximum in 2012 (0.875) in the case of life expectancy and reaches the minimum in 2006 (0.864) and the maximum in 1996 (0.938) in the case of infant mortality.

Figure 1

Trends in Mean Technical Efficiency with respect to Life Expectancy



addition, most sampled countries have been able to exploit also some catching up effect. Although the results are not reported, they are available from the authors upon request.

Figure 2
Trends in Mean Technical Efficiency with respect to Infant Mortality

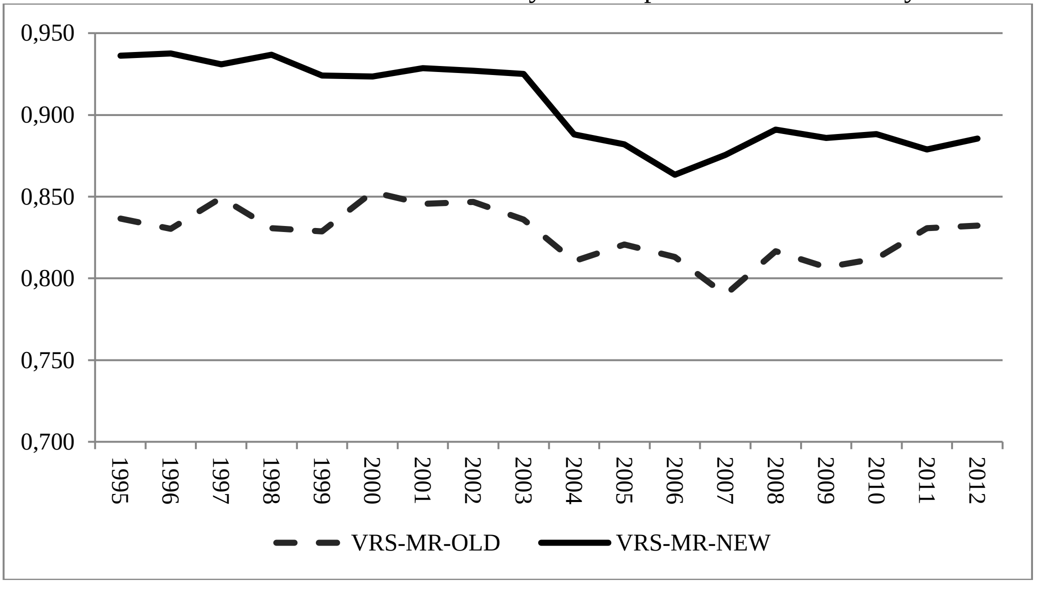


Figure 1 and 2 display the visual representations of the evolution of mean technical efficiency over the sample period according to life expectancy and infant mortality, respectively. As seen in Figure 1, although the mean technical efficiency fluctuates, the health systems in the old member countries became more efficient in recent years. As for the new member countries, the efficiency level decreases between 1999 and 2008, and it starts to increase after 2008. The gap between the old and new EU member countries increases during the period 2003-2010. However, the gap reduces significantly after this period. Overall, the health care systems became more efficient in recent years. As seen in Figure 2, there is no clear trend for both groups of countries. The mean technical efficiency levels do not fluctuate greatly over the sample period. The health care systems in the new member countries are on average more efficient than those of in the old member countries. However, as in the life expectancy case, the gap between two groups of countries in terms of efficiency levels decreases in recent years.

Table 4
Total Factor Productivity Scores by Years

	Old members		*New members and a candidate*	
Year	TFP-LE	TFP-MR	TFP-LE	TFP-MR
1996	2.712	1.575	2.550	1.494
1997	0.971	1.519	0.983	1.643
1998	0.892	1.065	0.896	1.033
1999	1.272	1.192	1.282	1.228
2000	0.575	0.549	0.577	0.539
2001	1.071	0.921	1.078	0.900
2002	1.209	1.159	1.202	1.167
2003	0.928	1.014	0.977	1.054
2004	1.673	1.282	1.540	1.202
2005	0.865	1.144	0.878	1.229
2006	1.018	0.985	0.987	0.909
2007	1.212	1.013	1.276	1.056
2008	1.071	1.260	1.074	1.234
2009	0.907	0.810	0.933	0.837
2010	0.965	1.105	1.013	1.157
2011	1.674	1.079	1.651	1.099
2012	0.935	0.762	0.913	0.680
Overall	***1.174***	***1.084***	***1.165***	***1.086***

Note: TFP-LE and TFP-MR denote total factor productivity with respect to life expectancy and infant mortality, respectively.

The Malmquist total factor productivity change for the health care systems of the EU member countries is reported in Table 4. The table reports TFP change with respect to both life expectancy and infant mortality. The results indicate that the health systems in the EU experienced a significant productivity growth over the sample period. For instance, the overall TFP index has grown on average by 17.4% (16.5%) during the sample period in the old member (new member) countries when life expectancy is considered as the output. Similar analysis can be done in the case of infant mortality. The results also indicate that the TFP index in the old and new member countries fluctuates greatly over the sample period. The TFP indices are mostly above one in the case of infant mortality. However, a regress in the TFP change has been observed in the case of life expectancy almost in the half of the sample period.

Table 5
Technical Efficiency Convergence: The Old and New EU Members and a Candidate Country

	Coefficient	Standard Error
Efficiency (life expectancy)		
β **- convergence**		
Constant	-0.116*	0.023
$\ln(Y_{i,t-1})$	-0.284*	0.043
$\overline{R}^2$	0.112	
F-statistic	3.135	0.000[a]
σ **- convergence**		
Constant	-0.066*	0.019
$D_{i,t-1}$	-0.263*	0.031
$\overline{R}^2$	0.104	
F-statistic	2.987	0.000[a]
Efficiency (mortality)		
β **- convergence**		
Constant	-0.147*	0.036
$\ln(Y_{i,t-1})$	-0.258*	0.060
$\overline{R}^2$	0.083	
F-statistic	2.535	0.000[a]
σ **- convergence**		
Constant	-0.107*	0.027
$D_{i,t-1}$	-0.268*	0.060
$\overline{R}^2$	0.087	
F-statistic	2.619	0.000[a]

Notes: * denotes significance level at 1%. $\overline{R}^2$ denotes adjusted *R*-squared. Country dummy variables are not reported. The third column represents the robust standard errors. [a] represent p-values for the F statistic. The LSDV model, which is determined by Hausman test, was used to estimate the convergence models.

The results of the regression for β*-convergence* and σ*-convergence* in technical efficiency are reported in Table 5. The technical efficiency scores with respect to both life expectancy and infant mortality are used in convergence analyses. Both tests are employed for the full sample of countries over the period 1995-2012. Specifications of convergence tests for panel data, which are presented in the methodology, are adopted. As seen from the table, the coefficients of $\ln(Y_{i,t-1})$ and $D_{i,t-1}$ are always negative and statistically significant at conventional level for both life expectancy and infant mortality cases, suggesting that both β-*convergence* and σ-*convergence* in technical efficiency have occurred among twenty-six EU members and a candidate country. The results suggest that the most efficient health care systems at the beginning of the sample period have shown a lower improvement rate both for life expectancy and for infant mortality than the least efficient health care systems (β-*convergence*). Moreover, the result also suggests that the dispersion of the technical efficiency scores among sampled countries declined over the sample period (σ-*convergence*).

Following the observed evolution of total factor productivity, convergence tests are of utmost interest so as to analyze the reality of a movement of convergence in health care system productivity across the old and new EU members and a candidate country. The results of the regression for β- *convergence* and σ-*convergence* in total factor productivity are reported in Table 6. Both tests are employed for the full sample of countries over the sample period. As seen in the table, the coefficients of $\ln(Y_{i,t-1})$ and $D_{i,t-1}$ are negative and statistically significant at the 1% level. These results indicate the evidence of both β-*convergence* and σ-*convergence* in productivity among twenty-six EU members and a candidate country. Hence, a main finding of this paper is the convergence in health care system productivity across EU members and a candidate country[10].

[10] The convergence in technical change is also investigated. The results indicate that the slope coefficients in the regressions are negative and statistically significant at conventional levels. Therefore, the results indicate the evidence of both beta-convergence and sigma-convergence in technical change among the sampled countries. Although results are not reported, they are available from the authors upon request.

Table 6
Productivity Convergence: The Old and New EU Members and a Candidate Country

	Coefficient	Standard Error
TFP (life expectancy)		
β **- convergence**		
Constant	-0.1467	0.111
$\ln(Y_{i,t-1})$	-1.471*	0.032
$\overline{R}^2$	0.716	
F-statistic	42.796	0.000[a]
σ **- convergence**		
Constant	-0.204***	0.112
$D_{i,t-1}$	-1.475*	0.032
$\overline{R}^2$	0.717	
F-statistic	44.175	0.000[a]
TFP (mortality)		
β **- convergence**		
Constant	-0.123	0.085
$\ln(Y_{i,t-1})$	-1.137*	0.025
$\overline{R}^2$	0.537	
F-statistic	20.288	0.000[a]
σ **- convergence**		
Constant	-0.147***	0.083
$D_{i,t-1}$	-1.142*	0.025
$\overline{R}^2$	0.540	
F-statistic	20.491	0.000[a]

Notes: * and *** denote significance levels at 1% and 10%, respectively. $\overline{R}^2$ denotes adjusted R-squared. Country dummy variables are not reported. The third column represents the robust standard errors. [a] represent p-values for the F statistic. The LSDV model, which is determined by Hausman test, was used to estimate the convergence models.

5. Conclusion

This paper investigates convergence both in technical efficiency and in total factor productivity for 26 member countries of the EU and a candidate (Turkey) country over the period 1995-2012. Particularly, we shift focus to the efficiency of the health care systems and its converging/diverging patterns in this paper. We use DEA, a non-parametric production frontier approach, to obtain the technical efficiency scores for the health care systems under consideration. The input-oriented specification of the DEA is used to measure technical efficiency since each decision-making unit can control the inputs but has no control over the outputs. Therefore, the attention has been paid to the issue of how much of the inputs could be saved to keep at least the present output level. Our empirical results suggest that the old members, on average, are slightly more efficient than the new members in the case of life expectancy. For input reduction, our findings reveal that the technically inefficient old (new) members can reduce inputs by 13.3% (15.4%) without reducing life expectancy. As for the infant mortality case, old (new) members are able to use only 82.7% (90.6%) of its current level of inputs and are still able to produce the same level of mortality rate. Hence, this would allow a 17.3% (9.4%) reduction in inputs without increasing mortality rate. In terms of infant mortality, the result indicates that the new member countries are more efficient than the old member countries. Our results show that three of the 27 countries (Bulgaria, Sweden, and Turkey) are fully efficient for both outputs.

Our efficiency results provide some policy implications by suggesting which output provides the greater improvement potential for a given country-group. For inefficient old member countries, additional resources will have greater impact if directed toward reducing infant mortality than increasing life expectancy. Alternatively, increasing life expectancy will provide more improvement for inefficient new members.

The Malmquist index approach is also employed to measure TFP change. The results indicate that the health systems in the EU experienced a significant productivity growth over the sample period. Overall TFP index has grown on average by 17.4% (16.5%) during the sample period in the old member (new member) countries when life expectancy is considered as the output. As for the mortality case, TFP index has grown on average by 8.4% (8.6%) during the sample period in the old member (new member) countries. Overall, a regress in the TFP change has been observed in the case of life expectancy in almost half of the sample period for both new and old member countries. According to the analysis of the decomposition of the Malmquist TFP, productivity growth in the sampled countries' health care systems seems to have been brought mainly by a positive technical change.

The results of convergence analysis suggest that both *β-convergence* and *σ -convergence* in technical efficiency and in productivity have occurred between twenty-six EU members and a candidate country over the sample period. This implies that the health care systems that have lower initial efficiency and productivity levels have the highest efficiency and productivity growth rates. Furthermore, the findings reveal that the dispersion of the technical efficiency and productivity scores among sampled countries declined over the sample period. Hence, the new member countries are catching up the old members.

Overall, the presence of convergence implies a greater degree of integration has been achieved within the countries of the EU. Integrating EU in the context of health will bring benefits to its member countries. Enhancing broader cooperation and promoting more regional integration in the health care systems allow countries to learn from each other by facilitating the transfer of expertise and knowledge, this in turn, could increase productivity and efficiency in these health care systems. The integration of the entire system complements, supports, and adds value to the policies of member states to improve the health status of the EU citizens and to reduce health inequalities. The differences in the productivity and efficiency levels across EU members could disappear in the near future. Hence, the coordination of health policies in the European Union and the EU Health Strategy "Together for Health" adopted in this regard in 2007 seem to have some positive impact on the convergence of efficiency and productivity of health systems in the region. Policy makers should put more efforts on the applications of the policies that coordinate the health systems in the EU.

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Özet

Sağlık sistemlerinde etkinlik ve verimlilik yakınsaması: AB üye ülkelerinden bulgular

Bu çalışma, yirmi altı AB üyesi ve aday bir ülkenin sağlık sistemlerinin teknik etkinlik ve verimlilik seviyelerinde bir yakınsama olup olmadığını 1995-2012 dönemi için araştırmaktadır. Yakınsama analizinin sonuçları, örneklem ülkelerin teknik etkinlik ve verimlilik seviyelerinde hem β (beta)-yakınsamasının hem de σ (sigma)-yakınsamasının gerçekleştiğini göstermektedir. Bulgular ayrıca, örnek ülkelerin teknik etkinlik ve verimlilik skorları arasındaki sapmanın ilgili dönemde azaldığına işaret etmektedir. Genel olarak, çalışmanın sonuçları Avrupa Birliği'ndeki sağlık sistemleri entegrasyonu sürecinin lehine kanıtlar sunmaktadır.

Anahtar kelimeler: Teknik etkinlik, verimlilik, yakınsama, sağlık sistemleri.

JEL kodları: I10, I11, I18.