EVALUATION of HEALTH INDICATORS of OECD COUNTRIES by STOCHASTIC FRONTIER ANALYSIS[1]

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ABSTRACT
Purpose: This study aims to determine the factors affecting the change of health expenditures in OECD countries and revealing their effect levels.
Methodology: Within the scope of the study, the effects of health status indicators on health expenditure per capita were investigated by using Stochastic Frontier Analysis (SFA) method with 2016 data obtained from OECD health statistics.
Findings: The extent to which health status indicators affect the change in health expenditures was tried to be calculated with the Least-Squares and Maximum Likelihood methods of the SFA. According to the estimation results, we observed that inefficiency reason in all analyses was due to a 99,99 % of random error. It was found in the analysis that there was a positive relationship between health expenditure per capita, life expectancy at birth, and the number of nurses per thousand people, and a negative relationship between infant mortality.
Originality: This study demonstrates the factors that have an impact on the health-care costs included in the health indicators, as well as the inter-relationship between such health indicators within the OECD countries. It is considered that familiarity with the inter-relationships among health indicators will be of great assistance to health-policymakers and will contribute to the body literature in the context of much more efficient plan preparation.
Keywords: OECD Countries, Stochastic Frontier Analysis, Health Indicators, Health Expenditures, Life Expectancy.
JEL Codes: D24, F53, H50.

OECD ÜLKELERİ SAĞLIK GÖSTERGELERİNİN STOKASTİK SINIR ANALİZİ YÖNTEMİYLE DEĞERLENDİRİLMESİ

ÖZET
Amaç: OECD ülkelerinde sağlık harcamalarının değişimini etkileyen faktörlerin belirlenmesi, etki düzeylerinin ortaya konulmasıdır.
Yöntem: Çalışma kapsamında OECD sağlık istatistiklerinden elde edilen 2016 yılı verileri kullanılarak sağlık statüsü göstergelerinin kişi başına düşen sağlık harcamasına etkileri Stokastik Sınır Analizi (SSA) yöntemi ile araştırılmıştır.
Bulgular: Sağlık statüsü göstericilerinin sağlık harcamalarının değişimini hangi ölçüde etkilediği Stokastik Sınır Analizinin En Küçük Kareler ve Maksimum Olabilirlik yöntemleri ile hesaplanmaya çalışılmıştır. Tahmin sonuçlarına göre tüm analizlerde etkinsizlik nedeninin %99,99 oranında rassal hatadan kaynaklandığı gözlemlenmiştir. Analizlerde kişi başına düşen sağlık harcaması ile doğumda beklenen yaşam süresi ve bin kişi başına düşen hemşire sayısı arasında pozitif, bebek ölüm oranı arasında ise negatif anlamlı ilişki olduğu tespit edilmiştir.
Özgünlük: Sağlık göstergelerinden sağlık harcamalarına etki eden faktörlerin ortaya konulmasını sağlayan bu çalışmada OECD ülkelerinin sağlık göstergeleri arasındaki ilişki gösterilmiştir. Sağlık göstergeleri arasındaki ilişkinin bilinmesi sağlık politika geliştiricilerine büyük kolaylıklar sağlayacak ve planlamaların çok daha etkin bir şekilde hazırlanması konusunda alanyazına katkı olacağı düşünülmektedir.
Anahtar Kelimeler: OECD Ülkeleri, Stokastik Sınır Analizi, Sağlık Göstergeleri, Sağlık Harcamaları, Yaşam Süresi.
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1. INTRODUCTION

The share of health expenditures in total expenditures, especially in developed and developing countries, is increasing steadily all over the world. The gradual aging of the population in the Organization for Economic Co-operation and Development (OECD) countries and the increase in chronic diseases accordingly show that health expenditures will increase in the upcoming years. Such a rapid increase in health expenditures makes it important to use health resources efficiently (Şener and Yiğit, 2017: 266).

One of the main objectives of the health reforms that have been at the top of the agenda for the last two decades all over the world, particularly in European countries, is related to how to improve the efficiency performance of healthcare systems. In other words, countries are under pressure to increase their performance such as the quality of healthcare systems, meeting expectations, fair financing, effectiveness, efficiency, etc. International organizations such as the World Health Organization (WHO) and the OECD develop various performance criteria and strategies to measure the efficiency of health systems and initiate health reform efforts that aimed at improving the performance of Health Systems (Yıldırım and Yıldırım, 2011: 26).

Stochastic boundary approach, also known as the econometric approach, establishes a functional relationship between the explained variables such as cost, profit and production, and explanatory variables such as input, output and environmental factors, and includes the error term in the model (Berger and Humphrey, 1997: 175). Although the most widely used method in healthcare efficiency measurement analysis is non-parametric data envelopment analysis, today stochastic frontier analysis, which is parametric, is also frequently preferred. In an analysis performed with this method, it can be revealed to what extent the dependent variable is affected by independent variables and the reasons for inefficiency.

The medical inputs that contribute significantly in the planning of health policies within health systems have a direct impact on the plans that will be developed for the health systems. Defining the interrelationship between health expenses and other health indicators, in particular, will greatly assist health policymakers. It is an undeniable fact that efficient system operation and effective use of inputs within the process of performing medical services will raise the level of outputs. In this context, any improvement in efficiency will have a positive impact on productivity. Revealing the relationships between health indicators in the labor-intensive health sector and the correct management of health expenditures provides great convenience to health policy developers and contributes to the literature on health efficiency in the field of making these health plans efficiently.

The importance of medical services has been best understood in the context of pandemics. The optimal use of the inputs used in the provision of medical services will have a positive effect on the output level of the health system. Setting out the interrelationships between health indicators across OECD countries will make it easier for policymakers to deal with health-care plans. The establishment of an efficient medical service provision system will assist people in gaining easy access to medical services at low cost. In this study, it is aimed to estimate the effect of different health inputs and outputs in the formation of per capita health expenditures in OECD countries in 2016.

The study includes 31 OECD countries. In the study, efficiency analyses were estimated within the framework of OLS and ML methods. In these methods, the Cobb-Douglas production function was used and tested with the hypothesis tests according to that. It was used “Health Expenditure Per Capita” as dependent variable; and “Smoking Rate (%, over 15)”, “Alcohol Consumption Per Year (Lt, over 15)”, “Number of Hospital Beds (per 1000 people)”, “Number of Doctors (per 1000 people)”, “Number of Nurses (Per 1000 people)”, “Infant Mortality (1000 live births per year)”, “Life Expectancy at Birth”. “Number of Doctor’s Examination per Person”, “Length of Hospital stay in Days” as independent variables within the scope of the analysis. Regression models created for this study after data were extracted from relevant sites displaying the relevant variables were tested.

The related literature was reviewed before conducting the study, and dependent and independent variables were defined as above. Then, the data of the related variables were obtained from the websites of the OECD, World Health Organization, World Bank, and the statistical institutions of the countries and made them usable in the study. Estimates were made with the Least Squares Method and Maximum Likelihood Method, the estimate results of both methods were analyzed by obtaining from the Eviews7 and SPSS-21 computer programs and the results were interpreted.

In the first section of the study, there is an introduction to the general framework of the study. In the second section, the relevant literature is given. In the third section, the theoretical background of the study method is presented. The findings of the study are given in the fourth section. In the fifth and sixth sections, discussion and conclusion sections are given based on the research findings.

2. LITERATURE REVIEW

Efficiency analyses in the health sector are performed by using the Parametric Data Envelopment Analysis (DEA) and Nonparametric Stochastic Frontier Analysis (SFA) methods. Brief information about some of the studies done for the health sector in recent years is given below.

In his study, Greene (2010) analyzed the effects of health expenditure and educational level of OECD and the World Health Organization (WHO) member countries, being apart and together, on the World Health Organization's measure of healthcare service acquisition with the data from 1993-1997. As a result of the study, the effect of health expenditures on the measure of healthcare service acquisition was found to be positively significant in member and non-OECD member countries, while the educational level was positively significant in non-member OECD countries and insignificant in OECD member countries.

In their study, Medeiros and Schwierz (2015) aimed to estimate the relative efficiency of healthcare systems across all EU countries and combinations of different input and output variables were used in the analysis performed with Data Envelopment Analysis and Stochastic Frontier Analysis methods. Life expectancy, healthy life expectancy and natural mortality rates are considered as outputs, and expenditures for healthcare services, physical inputs and environmental variables (per capita) are considered as inputs. On average in the EU, life expectancy at birth could be increased by 2,3% or 1,8 years, when moving from current positions to the efficiency frontier.

In his study, Yardımcıoğlu (2012) investigated the long-term relationship between health (life expectancy level) and economic growth for the period 1975-2008 by using data of 25 OECD countries. In the study, Pedronicointegration test, Pedroni FMOLS test and Canning- Pedroni panel causality analysis was used. Pedroni cointegration test showed that both variables have a cointegration relationship in the long term and according to Pedroni FMOLS test results, the flexibility of the health all across the panel was calculated as 0,18% and the flexibility of the economic growth variable was calculated as 0,17%. According to the Lamda-Pearson statistics which is one of the causality studies performed, panel causality results for the overall panel showed bilateral causality relationship between health and economic growth in the long-term. In this context, it is concluded that there is a mutually significant relationship between health and economic growth variables in OECD countries in the long term.

In their study, Vorobeva and Schreyögg (2013) compared the technical efficiency of the hospital sector using the panel data of OECD countries during the period 2000-2009. Estimate of the technical efficiency of the hospital sector was performed by using nonparametric DEA and parametric SFA. It was found with panel data analysis that countries with high health expenditure per capita tend to have a technically more efficient hospital sector. It was determined whether or not the expenditures were financed by private or public resources, whether or not it is related to the technical efficiency of the hospital sector and, on the other hand, the technical efficiency of the hospital sector was lower in countries with higher income inequality and length of hospital stay (average number of days stayed).

In the study performed by Kaya Samut and Cafri (2016), the hospital efficiency was measured with DEA in 29 OECD countries between 2000 and 2010 and then Panel Tobit Analysis was used to determine the environmental factors affecting the efficiency scores achieved. In addition, changes in factor efficiency were investigated with the Malmquist Productivity Index compared to previous years. As a result of the study, it was found that the efficiency scores obtained after 2000 began to decrease in 2004 and bottomed out in 2009-2010. Among the environmental factors affecting hospital efficiency, it was found that the efficiency of income and educational level of the population and number of private hospitals effected positively and the efficiency of number of public-private health expenditures and number of public hospitals effected negatively.

In his study, Yu (2016) used DEA and SFA methods in order to measure the efficiency of the public and private health sector by using data from 2009 with 31 OECD countries and compared the results. In his study, the share of health expenditures in GDP and health expenditure per capita were used as input and preventable mortality was used as output. As a result of the study, it was found that underdeveloped countries were grouped around developed countries such as USA and Japan in both public and private sectors.

In their study, Yeşilyurt and Salamov (2017) comparatively evaluated the efficiency of healthcare systems of Turkey, Azerbaijan, Kazakhstan, Turkmenistan, Kyrgyzstan and Uzbekistan with DEA and Tobit analysis methods and the factors affecting the efficiency. As a result of the efficiency analysis performed in study with Charnes-Cooper-Rhodes (CCR) and Banker-Chaenes-Cooper (BCC) models, the efficiency scores of Kyrgyzstan and Uzbekistan were below 1. In the Tobit analysis performed according to the scores obtained with the CCR method, it was concluded that both outputs had a positive effect on efficiency, but the “average life expectancy” output was insignificant, and “the number of operations per hundred thousand people” had 10% significance level. In the Tobit analysis performed according to the efficiency scores obtained with the BBC method, it was concluded that both output coefficients had a positive effect on the efficiency, but the results had 5% level of significance.

In his study, Dursun (2017) examined the stochastic convergence behavior of real GDP per capita for the period of 1948-2010 and 1900-2010 among 20 OECD countries. For this purpose, Fourier IPS test was applied and the test findings produced different results for both periods. It was observed that the analysis results supported stochastic convergence for all countries except Austria, Belgium and Japan in the period of 1948-2010, and the standard deviation values for σ-convergence for the whole period tended to decline. According to the results obtained, it was understood that the differences in per capita real income gap during the post-war period were eliminated in most of the 20 OECD countries, and country-specific shocks had a temporary effect on per capita real income in the long-term.

In the study of Karasaç and Sağın (2018), the effects of health expenditures on economic growth in 34 OECD countries were examined. Analysis was performed principally by Panel Unit Root tests and Panel Cointegration, and then Panel Fully Adapted Least Squares Estimation and Vector Error Correction Model were used. According to the result of the study, it was found that there is a linear relationship between health expenditures and GDP for OECD countries, and increases in health expenditures also increase national income.

This study differs from others in the literature in that it uses stochastic frontier analysis on 2016 data from OECD countries to establish the relationship between health indicators. This study provides information about health policies by presenting the interrelationship between health indicators. The lowest, highest, mean values and standard deviations of the variables used within the scope of the study are provided herein as well as the medical statistics. The reason to use the parametric stochastic frontier analysis method in this study is to be able to reveal the relationship between the dependent variables and the independent variables more clearly. In addition, this method reveals to what extent the change in the independent variable affects the change in the dependent variable. Unlike data envelopment analysis, this method also allows calculating the random error rate, which is the inefficiency reason.

3. METHODOLOGY

In the literature, efficiency is expressed as an indication of how existing resources are used to provide useful output and as a value found by comparing input elements to standards (Yolalan, 1990: 132 and Bayraktutan and Pehlivanoğlu, 2012: 131). Debreu and Koopmans conducted the first empirical studies of the “Farrell-type Approach of Efficiency Measure” developed by Farrell (Murillo-Zamorano et al., 2000: 1). Nonparametric DEA and SFA methods were preferred by researchers while making efficiency analyses developed afterwards. One of the main reasons for this is to be able to use multiple and different inputs and outputs in the efficiency analysis. With this advantage, it is not possible to determine the reasons of inefficiency in DEA analysis and to measure why it resulted from.

3.1. Stochastic Frontier Analysis (SFA)

Stochastic Frontier Analysis (SFA) is defined as an approach that is used to estimate the boundary functions of the production and measure the efficiency by looking at the study in which the production is done efficiently. By generating econometric models, SFA tries to estimate the errors that occur during production and to minimize the inefficiency caused by these errors as much as possible (Avcı and Çağlar, 2016: 20). Efficiency measurement carried out using SFA method is performed with multiple regression techniques that investigate the relationship between single output and multiple inputs and the parameters in the function are tried to be estimated. Here, the effects considered to cause changes in dependent variables are attempted to be determined. It is recognized that the inefficient components of the production are those deviating from the boundary, and may also be caused by random and/or technical error, which is observed to be zero at the full efficient production boundary (Kutlar et al., 2011: 88-92).

The SFA method was developed under the leadership of Aigner, Lovell and Schmidt (1977) and Meeusen and Van Den Broeck (1977) to separate between random effects and causes of inefficiency in order to find the deviation occurred due to inefficiency.

For simplicity, maximization of y single output in the Cobb-Douglas production function in classical economy calculations is performed by using x_1 and x_2 inputs as in Equation 1 (Cooper, Tone 1997).

$$y = a x_1^{\alpha_1} x_2^{\alpha_2} e^{v} \tag{1}$$

This function determines the technological (exact) boundary of efficiency for which observations must comply with. We need to allow statistical errors for these calculations, where the boundaries for the a, α_1 and α_2 parameters estimated from the observed data will only be defined as stochastic. And these statistical errors are represented by v in the Equation 1. Statistical error terms can be added to each y values by selecting them from the $v_i \sim iid$ N (0, σ^2_v) distributions by sampling. iid (independent, identically distributed) means independent, zero mean and constant variance distribution. Cooper and Tone (1997) used the “error generation” of the SFA method as follows:

$$\ln y = \beta_0 + \beta_1 \ln \hat{x}_1 + \beta_2 \ln \hat{x}_2 + v - u \tag{2}$$

In Equation 1, β’s are assigned as estimators for a, α_1 and α_2 in Equation 1. (υ - u) is added to the equation, where υ is the random variable that is independently distributed and represents the N (0, σ_υ^2) distribution, and u ($u \geq 0$) is the variable that measures technical inefficiency which does not take any negative value.

The term $u \geq 0$ generation in terminology is referred to as “forgone outputs” and it is formulated as follows being interpreted the meaning of estimating the accessibility in situ in response to the $\hat{x}_1 \geq x_1$ ve $\hat{x}_2 \geq x_2$ inputs of y value actually observed this amount of extra output.

In general, it is assumed that each random variable of v_i` is distributed independently of each u_i variable and both error terms are unrelated to their explanatory variables. In SFA, it is made following assumptions Equation 3 for the random variable (Kutlar, 2012: 32-33):

$$E(vi|Xi) = 0 \quad (3)$$

It means that the average of the disturbance term is zero within the *x* values given. When it is discussed the co-variance for the term v_i`, the variance of v_i for each X_i would be constant and positive. This assumption is expressed as follows (Equation 4):

$$Variance (vi | Xi) = E [vi - E(vi) | Xi]2 = E(vi2 | Xi) = \sigma v2 \quad (4)$$

Following assumptions of distribution are used to obtain Maximum Likelihood (ML) estimates of the stochastic production boundary (Aigner et al. 1977: 28). These assumptions (Equation 5) are the distribution of $v_i \sim iid\ N(0, \sigma_v^2)$ together with $u_i \sim$ iid $N+ (0, \sigma_u^2)$ series. It is equal to the sum of σ^2 random variable or random error variance σ^2_v and the variance of technical inefficiency σ^2_u (Coelli, 1996: 5).

$$\sigma 2 = \sigma 2v + \sigma 2 \quad (5)$$

The γ value, which measures the significance of the estimate, is equal to σ^2_u/σ^2, but shows from which of them the inefficiency is caused by. This is formulated in Equation 6:

$$\gamma = \frac{\sigma_u^2}{\sigma_u^2+\sigma_v^2} = \frac{\sigma_u^2}{\sigma^2} \quad (6)$$

In the study performed, *t* significance test is performed for the regression coefficients. The statistic *t*, which indicates whether or not the obtained results validate the zero hypothesis, was developed from the 1960s (Kutlar, 2012).

Estimate results were obtained from related computer programs and then analyzed. Significance levels of the estimate values are given as p≤ (0,01), p ≤ (0,05), p ≤ (0,10). Especially, the values equal to or below 0,05 indicate that they have a determining role in increasing efficiency.

3.2. Data and Variables

In the study, the efficiency analysis of the healthcare system of 31 countries that are members of the Organization for Economic Co-operation and Development (OECD) was performed by using the SFA method. As a result of review of the websites of OECD, World Health Organization, World Bank and the statistical institutions of the countries, since only health related data of 2016 could be obtained, research has been carried out by using the data of that year. Although it was noticed that the data of the determined variables would be belonged to the same year, data of the earliest year was used, because some data could not be obtained. Since the data on the variables used before 2016 changed proportionally over the years, it is assumed that it will not affect the analysis results. Moreover, although Norway, Greece, Israel and the UK are the member countries the OECD, some data related to the selected variables were excluded from the study since they could not be obtained.

The Least Squares (OLS) and Maximum Likelihood (ML) methods are generally used in the studies performed by SFA method to investigate health efficiency. Following functions were generated with the variables used in the study (Equations 7-14):

$$lnExpenditure = \beta_0 + \beta_1 lnSmoking + \beta_2 lnAlcohol + \beta_3 lnDoctor + \beta_4 lnNurse + \beta_5 lnBed + \beta_6 lnLife + \beta_7 lnInfant + \beta_8 lnExamination + \beta_9 lnBed + v_i - u_i \quad (7)$$

$$lnExpenditure = \beta_0 + \beta_1 lnDoctor + \beta_2 lnNurse + \beta_3 lnBed + \beta_4 lnLife + \beta_5 lnInfant + \beta_6 lnExamination + \beta_7 lnHospitalization + v_i - u_i \quad (8)$$

$$lnExpenditure = \beta_0 + \beta_1 lnDoctor + \beta_2 lnNurse + \beta_3 lnBed + \beta_4 lnLife + \beta_5 lnInfant + v_i - u_i \quad (9)$$

$$lnExpenditure = \beta_0 + \beta_1 lnDoctor + \beta_2 lnNurse + \beta_3 lnLife + \beta_4 lnInfant + v_i - u_i \quad (10)$$

$$\text{lnExpenditure} = \beta_0 + \beta_1\text{lnLife} + \beta_2\text{lnInfant} + \beta_3\text{lnExamination} + \beta_4\text{lnHospitalization} + v_i - u_i \quad (11)$$

$$\text{lnExpenditure} = \beta_0 + \beta_1\text{lnDoctor} + \beta_2\text{lnNurse} + \beta_3\text{lnBed} + v_i - u_i \quad (12)$$

$$\text{lnExpenditure} = \beta_0 + \beta_1\text{lnDoctor} + \beta_2\text{lnNurse} + v_i - u_i \quad (13)$$

$$\text{lnExpenditure} = \beta_0 + \beta_1\text{lnSmoking} + \beta_2\text{lnAlcohol} + v_i - u_i \quad (14)$$

In the calculation of efficiency estimates, it was used “Expenditure” (Health Expenditures Per Capita) as a dependent variable and “Smoking” (Rate of Smoking Per Capita over 15), “Alcohol” (Alcohol Consumption Per Capita Per year over 15 (Lt), “Doctor” (Number of Doctors per 1000 people), “Nurse” (Number of Nurses per 1000 people), “Bed” (Number of Hospital Beds per 1000 people), “Life” (Life Expectancy at Birth), “Infant” (Infant Mortality per 1000 live births per year) “Examination” (Number of Doctor’s Examinations Per Person) and “Hospitalization” (Length of Hospital Stay in Days) as independent variables.

In the regression equality, the log-transformed states of the variables are evaluated, and hypotheses are formed as follows:

1. H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = 0$; H_1: Minimum one Parameter ≠ 0
2. H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$; H_1: Minimum one Parameter ≠ 0
3. H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$; H_1: Minimum one Parameter ≠ 0
4. H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$; H_1: Minimum one Parameter ≠ 0
5. H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = 0$; H_1: Minimum one Parameter ≠ 0
6. H_0: $\beta_0 = \beta_1 = \beta_2 = 0$; H_1: Minimum one Parameter ≠ 0

Statistical summaries of the variables used within the scope of study are presented in Table 1. As it is seen from the statistical summary, health expenditure per capita is lowest at 1020,30 (Mexico), maximum 9832,32 (USA), and the average is 3949,35. Number of countries with above average health expenditure per capita is 16 out of 31 countries. Rate of smoking was lowest at 7,60 (Mexico), highest at 26,50 (Turkey) and the average was 18,49. The number of countries above average was 17. Alcohol consumption rate was lowest at 1,30 (Turkey), highest at 11,70 (France), and the average was 9,13. The number of countries above average was 17. The number of doctors per thousand people was lowest at 1,80 (Turkey), highest at 5,10 (Austria), and the average was 3,30 and the number of countries above average was 14. Number of nurses per thousand people was lowest at 1,90 (Turkey), highest at 17,00 (Switzerland), and the average was 9,09 and the number of countries above average was 17.

Table 1. Statistical indicators of variables

Variables	Lowest	Highest	Average	Std. Deviation
Expenditure	1020,30 (Mexico)	9832,32 (USA)	3949,35	2012,16
Smoking	7,60 (Mexico)	26,50 (Turkey)	18,49	4,91
Alcohol	1,30 (Turkey)	11,70 (France)	9,13	2,23
Doctor	1,80 (Turkey)	5,10 (Austria)	3,30	0,78
Nurse	1,90 (Turkey)	17,00 (Switzerland)	9,09	3,97
Bed	1,52 (Mexico)	13,11 (Japan)	4,82	2,70
Life	74,70 (Lithuania)	84,10 (Japan)	80,65	2,51
Infant	0,70 (Iceland)	12,10 (Mexico)	3,92	2,30
Examination	2,80 (Sweden)	17,00 (South Korea)	7,02	3,21
Hospitalization	3,80 (Mexico)	28,50 (Japan)	8,27	4,51

As it is seen from Table 1, the number of hospital beds per thousand people is lowest at 1,52 (Mexico), highest at 13,11 (Japan), and the average is 4,82, and the number of countries above average is 11. Life expectancy at birth is lowest at 74,70 (Lithuania), highest at 84,10 (Japan), and the average is 80,65, and the number of countries above average is 21. Infant mortality is lowest at 0,70 (Iceland), highest at 12,10 (Mexico), and the average is 3,92 and the number of countries above average is 8. The number of examinations per person is lowest at 2,80 (Sweden), highest at 17,00 (South Korea), the average is 7,02, and the number of countries above average is 12. Length of hospital stay of patients is lowest at 3,80 (Mexico), highest at 28,50 (Japan), and the average is 8,27 and the number of countries above average is 11. The variable with the highest standard deviation was the expenditure variable (2012,16). The variable with the lowest standard deviation was the number of doctors (0,78).

Table 2 shows the correlations between dependent and independent variables. We observed that the correlation coefficient between the variables “Nurse” and “Expenditure” and “Examination” and “Bed” was over 75%. It was calculated that this coefficient was 60% between the variables of “Life” and “Nurse”, and “Examination” and “Hospitalization” variables, and 85% between the “Hospitalization” and “Bed” variables.

We observed that other correlation coefficients were too close to 0, 0, or even less than 0. If the value of the correlation coefficients is positive, it indicates that there is a relationship between the two variables in the right direction. If it is negative, there is a relationship in the opposite direction. If the correlation coefficient is 0, it means that there is no relationship between the two variables. The variables getting 0 correlation coefficient within the data were “Doctor” and “Smoking”.

Table 2. Correlation between variables

	Expenditure	Smoking	Alcohol	Doctor	Nurse	Bed	Life	Infant	Examination
Smoking	-0,36								
Alcohol	0,23	0,21							
Doctor	0,26	0,00	0,41						
Nurse	**0,76**	-0,42	0,29	0,33					
Bed	-0,05	0,34	0,30	-0,07	0,02				
Life	0,53	-0,22	0,07	0,30	**0,57**	0,11			
Infant	0,07	-0,28	0,03	0,28	0,39	0,07	0,33		
Examination	-0,24	0,36	0,08	-0,21	-0,18	**0,79**	0,02	0,03	
Hospitalization	0,03	0,11	0,09	-0,16	0,09	**0,85**	0,32	0,13	**0,60**

4. EMPIRICAL RESULTS

Before interpreting the estimate results obtained from the regression, it should be examined whether or not there is an excellent multicollinearity relationship between the independent variables and the important assumptions regarding the linear regression model, a heteroscedasticity for the term u_i and an autocorrelation relationship between disruptive terms. If one of these problems exists, it makes the estimate results of the regression parameters difficult and even impossible.

In the analysis performed to examine whether or not there is multicollinearity, the result obtained in all estimates was found to be less than 5 and it was observed that there was no multicollinearity problem in regression equality.

When the $n*R^2$ value obtained as a result of the White test regression is greater than the X^2 table value, it is assumed that there is a different variance problem, and when it is small, the same variance is accepted, then it is assumed that there are different variance problems in the equalities whose independent variables are InDoctor, lnNurse, lnLife and InInfant, and InSmoking and InAlcohol, but not in other equalities. Therefore, the interpretation of these two equalities will not be included in the study.

When examining the Durbin-Watson *d* statistic values, it is concluded that there are no positive autocorrelations between the random variables in the equalities with independent variables of InDoctor, lnNurse and lnBed, InSmoking and InAlcohol and InDoctor and InNurse. In other equalities, it cannot be determined whether or not there is a positive autocorrelation among random variables and it is undecided about whether or not this problem exists. This does not mean that there is an autocorrelation relationship between random variables as it is not said to be.

In order to clear up these problems in question, the number of independent variables is usually reduced and regression analysis is performed with appropriate independent variables. The equalities that we can fully accept as safe within the scope of the study are the 6th (independent variables: “Doctor”, “Nurse” and “Bed”) and 7th (independent variables: “Doctor” and “Nurse”) regression equalities.

As is seen in Table 3 and Table 4, it was observed that “Number of Nurses per 1000 people” and “Life Expectancy at Birth” were used in the OLS estimates made, that the t values of β coefficients of the logarithmic value of the numbers were greater than 2 and p probability values were less than significance level of 0.01 and that there is a positive relationship between the dependent variable of “Health Expenditures Per Capita”. In this case, it is estimated that the “Health Expenditures Per Capita” will increase as “Life Expectancy at Birth” and “Number of Nurses per 1000 people” increase. Moreover, in the 1st, 2nd, 3rd and 4th regressions, it was estimated that there was a negative significant relationship between the dependent variable of “Infant Mortality (per 1000 live births)”, where the coefficients at 5% significance level was significant. It is estimated that the “Health Expenditures Per Capita” will decrease by 0,3% as a result of increase in the “Infant Mortality Rate” by 1%. In the 8th regression, the effect of smoking and alcohol use on health expenditures in OECD countries was examined, and β coefficients in smoking were found to be significant at the level of 10% and alcohol use at the level of 1%. It was found that there was a positive relationship between the dependent variable and alcohol use and a negative relationship between the dependent variable and smoking.

Table 3. Estimate results (Independent variable: lnExpenditure)

Variables	**1. Regression Coefficient**	**2.Regression Coefficient**	**3. Regression Coefficient**	**4. Regression Coefficient**
Constant	-24,48** (-2,52)	-24,03** (-2,76)	-22,7*** (-3,01)	-22,92*** (-3,12)
lnSmoking	0,11 (0.50)			
lnAlcohol	0,077 (0,449)			
lnDoctor	0,07 (0,26)	0,15 (0,61)	0,19 (0,88)	0,19 (0,94)
LnNurse	0,79*** (4,93)	0,78*** (6,43)	0,80*** (7,20)	0,80*** (7,34)
lnBed	0,01 (0,03)	0,07 (0,33)	-0,02 (-0,23)	
lnLife	6,90*** (2,98)	6,87*** (3,36)	6,51*** (3,77)	6,55*** (3,90)
lnInfant	-0,31** (-2,42)	-0,32** (-2,59)	-0,33*** (-2,84)	-0,34*** (-3,12)
lnExamination	-0,08 (-0,41)	-0,08 (-0,48)		
lnHospitalization	-0,06 (-0,24)	-0,07 (-0,29)		
Log Likelihood	4,94***	4,53***	4,36***	4,32***
R^2	0,86	0,85	0,26	0,85
Adjusted R^2	0,79	0,81	0,21	0,83
Estimated Standard Error	0,25	0,24	0,49	0,23
F Statistic	13,87***	18,93***	28,45***	36,89***
σ_v	0,21	0,21	0,21	0,21
σ_u	0,00	0,00	0,00	0,00
σ^2	0,04	0,04	0,04	0,04
Γ	0,00	0,00	0,00	0,00
Λ	0,01	0,01	0,01	0,01
VIF	3,42	3,13	1,63	1,69
White Test	31,00	30,88	25,73	24,76**
Durbin-Watson Test	1,28 Inconclusive	1,35 Inconclusive	1,39 Inconclusive	1,39 Inconclusive

**p ≤ 0,10; **p ≤ 0,05; ***p ≤ 0,01*

As is seen in Tables 3 and 4, the fact that the value of R^2 was about 0,9 and the adjusted R^2 values was about 0,8 in the 1st, 2nd and 4th regressions, shows that approximately 90% of the total change in the dependent variable is explained by the change in the independent variables. In the 6th and 7th regressions, the fact that R^2 and the adjusted R^2 values were about 0,7 shows that approximately 70% of the total change in the dependent variable was explained by the change in the independent variables. In the 5th regression, that fact that the R^2 value was about 0,5 and the adjusted R^2 values were about 0,4, shows that approximately 50% of the total change in the dependent variable was explained by the change in the independent variables. In the 3rd and 8th regressions, the fact the R^2 value was about 0,3 and the adjusted R^2 values were about 0,2, shows that approximately 30% of the total change in the dependent variable is explained by the change in the independent variables.

Table 4. Estimate results (Independent variable "InExpenditure")

Variables	5. Regression Coefficient	6. Regression Coefficient	7. Regression Coefficient	8. Regression Coefficient
Constant	-42,4*** (-3,40)	6,43*** (20,76)	6,30*** (22,16)	8,28*** (8,81)
InSmoking				-0,51* (-1,73)
InAlcohol				0,62*** (2,81)
InDoctor		0,02 (0,07)	0,03 (0,11)	
LnNurse		0,89*** (7,77)	0,87*** (7,71)	
InBed		-0,11 (-1,02)		
InLife	11,61*** (4,10)			
InInfant	0,07 (0,41)			
InExamination	-0,22 (-1,09)			
InHospitalization	0,05 (0,18)			
Log Likelihood	-13,7***	-4,07***	-4,66***	-19,4***
R^2	0,52	0,74	0,73	0 ,26
Adjusted R^2	0,45	0,71	0,71	0,21
Estimated Standard Error	0,41	0,30	0,30	0,49
F Statistic	7,04***	25,95***	38,33***	5,02**
σ_v	0,38	0,28	0,28	0,24
σ_u	0,00	0,00	0,00	0,67
σ^2	0,14	0,08	0,08	0,51
Γ	0,00	0,00	0,00	0,89
Λ	0,01	0,01	0,01	2,85
VIF	1,48	1,21	1,27	1,01
White Test	10,36	12,15	3,98	18,67***
Durbin-Watson Test	1,07 Inconclusive	1,64 Accept.	1,65 Accept.	1,38 Accept.

**p ≤ 0,10; **p ≤ 0,05; ***p ≤ 0,01*

When examining the γ values obtained as a result of the Maximum Likelihood analysis, it was seen that in all other regressions, except for the regression where the independent variable was "InSmoking" and "InAlcohol", all inefficiencies were caused by random error. In these regressions, it means that the results obtained with the ML method are the same as those obtained with the OLS method. In the regression analysis, in which the independent variable is "InSmoking" and "InAlcohol", it was determined that the reasons of inefficiency were caused by technical inefficiency at 89% as a result of maximum likelihood analysis.

The values of F statistic derived from the regressions are determinant in testing whether or not the parameters of independent variables differ from 0 (Kutlar, 2012: 133). The H_0 hypothesis was rejected because the F value calculated in all regressions exceeded the critical F values in the F table at the significance level of 1% and 5%.

5. DISCUSSION

When the findings of the study are compared with previous similar studies, it is seen that analyzes for the healthcare systems of OECD countries are generally based on panel data analysis. For example, it has been investigated the long-term relationship between the life expectancy level and economic growth for the period between 1975 and 2008 (Yardımcıoğlu (2012) and Karasaç and Sağın (2018)) and according to the test results, the flexibility of the health across the panel was calculated as 0,18% and the elasticity of the economic growth variable as 0,17%, a long-term bilateral causality relationship was found between health and economic growth, and it was determined that increases in health expenditures also increased national income. From the study, the positive effect of the number of nurses and the life expectancy on the health expenditures and the negative effect of the infant mortality seem to coincide with similar studies in the literature.

That is to say, in the Stochastic Analysis conducted for the period of 2000-2009, a positive and significant relationship was found between the number of patients discharged and Expenditure, Hospital bed density, Infant mortality, Full-time employment, and technically, countries with more efficient hospital sectors have been found to tend to have higher healthcare expenditures per capita (Vorobeva and Schreyögg (2013)). In another study conducted with 31 OECD countries by using data from 2009, the level of relationship between total a mortality and health expenditures was found to be same (Yu, (2016)). In another study, in which the relationship between per capita healthcare expenditure and life expectancy at birth was investigated for the European Union countries, similar results were obtained (Medeiros and Schwierz (2015)).

In conclusion, since these analyses revealed a significant relationship between health status indicators and healthcare expenditures, it is estimated that both private and public sector investments in healthcare services would increase the quality of human capital in economies. Therefore, it should be further increases in health care expenditures, especially emerging economies such as Turkey. It is important that Turkey, which is in the last ranks among the analyzed countries, should bear healthcare expenditures to the average of OECD countries as soon as possible. Thus, it is thought that human capital increased will accelerate economic growth and development by increasing the production quality and efficiency.

6. CONCLUSION

In today's world, the development of health, increasing health expenditures per capita and efficient service delivery constitute one of the main aspects of social policy. Efficient creation and implementation of health-related policies has a particular importance.

In the study, the efficiencies of health sector of the countries that are members of the OECD are estimated by using the SFA method. The limitation of this study is the inaccessibility of data for some countries (Norway, Greece, Israel, and the United Kingdom). Another limitation is the inability to find the current data of the countries for the relevant dates of study.

In the study, efficiency analyses were estimated within the framework of OLS and ML methods. In these methods, the Cobb-Douglas production function was used and tested with the hypothesis tests according to that. It was used "Health Expenditure Per Capita" as dependent variable; and "Smoking Rate (%, over 15)", "Alcohol Consumption Per Year (Lt, over 15)", "Number of Hospital Beds (per 1000 people)", "Number of Doctors (per 1000 people)", "Number of Nurses (Per 1000 people)", "Infant Mortality (1000 live births per year)", "Life Expectancy at Birth". "Number of Doctor's Examination per Person", "Length of Hospital stay in Days" as independent variables within the scope of the analysis. In the study, estimates were first made with the OLS method and then with the ML method, and as a result of the analysis, it was determined that the cause of inefficiency was caused by random error in all regressions and therefore, the estimates of ML method were equal to the results of the OLS method.

By increasing the number of variables and countries, this study could be conducted in all countries around the world with available data. Furthermore, studies for the 81 provinces where all the variables used in the contents of this study are available may be conducted. In addition, it is recommended to carry out similar studies for OECD and other countries in the world by obtaining actual data and using different variables.

According to the estimate results of the OLS method made by using Cobb - Douglas function, the coherence of the coefficients of "Number of Nurses per 1000 people" and "Life Expectancy at Birth" to the dependent variable of "Health Expenditure Per Capita" is positive and significant, and coherence to dependent variable of "Infant Mortality (1000 births per year)" was negative and insignificant. It was seen that there was no significant relationship between other independent variables (smoking, alcohol, doctor, bed and examination) and dependent variable (health expenditure). In addition, it can be said that there is no heteroscedasticity and multicollinearity problem in regression, and no positive autocorrelation among random variables.

It is a fact that the countries with high elderly population are generally developed countries. Elderly population (over 65 years) is an age group having quite considerable chronic diseases. Consequently, the rate of utilization from health services in the countries with high elderly population is much higher than the countries with young population. This causes high health expenditures in countries with a high elderly population. Another situation caused by the high elderly population is to create need for ancillary medical staff. It requires an increase in the life-assisted health services with the increase in the elderly population. Therefore, increase in the number of nurses and average life expectancy leads to an increase in health expenditures.

Another attention-grabbing result in the analysis is that health expenditures are low in countries with high infant mortality. Because the countries having high infant mortality are generally underdeveloped countries, healthcare services cannot be provided enough. Therefore, health expenditure is much lower in underdeveloped countries than in developed countries. Analysis results provided results validating this situation.

The policies followed by the states regarding the efficiency of health services differ in the literature. The reasons are the prevalence of diseases seen in countries and the differences in health status, geographical position, economic, social, and educational level, and management style from country to country. Therefore, it is necessary to develop and plan health policies by considering these differences. However, there are also some methods and factors common in the literature on health care delivery efficiency. The efficiency of health care services depends on improving the existing inputs and health indicators and increasing the performance of health institutions. In addition, because the health sector is a labor-intensive sector, it should be cared to use health inputs more effectively. Correct management of health-related expenditures is considered a factor that will increase the effectiveness of health indicators. It is thought that this study will provide great convenience to health care policy developers in terms of revealing the relationships between health indicators and will contribute to the literature within the context of productivity theory in making health plans much more effectively.

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