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Research Article

A TRENDLINE ANALYSIS FOR HEALTHCARE EXPENDITURE PER CAPITA OF OECD MEMBERS

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ABSTRACT

The aim of this study was to predict the per capita health expenditures (HE PC) of OECD countries for the future. Datasets were used to evaluate the accuracy of HE PC estimation of OECD members from 2000 to 2017 shared online by OECD DATA in this study. Forecasting calculations about HE PC cover the years 2018-2025. Estimation series method derived by trend-line equations was used to make any predictions for the future years in the methodology part of the present research. A trend line analysis by generating one linear equation and seven non-linear equations was carried out within this study. The minimum value of the amount of the HE PC was counted as $3,930.13 with the 4th order equation for the year 2018 and the highest amount was calculated as $5,760.47 for the year 2025 with the equation of exponential distribution. The average amount of the HE PC was calculated as $4,616.62 which can be argued as a decrease in the budget allocated for the HE PC. The minimization of the standard error of the mean level was the secondary goal of the work in order to ensure that the results obtained for estimation were consistent with the data used. Predictive equations for HE PC values were found to be suitable for use as a consistent analysis tool for future outcomes. It can be emphasized that there is no drawback in the use of estimation equations for other indicators in the field of healthcare, as only the use for HE PC was verified in this study.
Keywords: Health expenditures per capita, OECD members, estimation series, trendline analysis.

1. INTRODUCTION

Developed and developing countries have aimed to reform the economic fields in order to increase the economic and also social welfare of the people living in the world. The most important issue encountered in terms of economics is healthcare problems. Healthcare economy is among the most significant parameters taken into consideration in developed countries with the increasing importance of health field for humanity in today's world. The main reason for this situation can be defined as the desire of people to live more. As such, the progress in the field of healthcare is directly proportional to the national economy. The budget allocated by the developed countries (i.e.; members of The Organization for Economic Cooperation and Development-OECD and The Group of Twenty-G20) for healthcare expenditures (HEs) is

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approximately $ 6.02 trillion [1]. However, as the size of the countries' economies cannot be an indicator of the welfare level in those countries, the size of the HEs of the countries does not demonstrate the developmen t of health systems they have. Consequently, per capita health expenditure (HE PC), which is one of the most important indicators of the development of healthcare systems, is taken into consideration in this study.

A number of scientific studies have been carried out regarding the factors triggering HE-PC in developed countries. In general, the relationship between health economics and economic dimensions of countries has been investigated in the literature. A study of 19 OECD countries in 1992 addressed institutional and socio-demographic factors affecting HEs [2]. In another study conducted in 2010, the relation of gross domestic product per capita (GDP PC) with HE PC was examined for OECD countries with 20 members from 1971 to 2004. As a result of this study, the researchers emphasized that the amount of HE PC was strongly correlated with the amount of GDP PC [3].

Nowadays, since technological advances directly affect the scope and quality of healthcare services, it is not possible that the amount of HE PC is not impacted by this factor. Some new technologies increase health costs by offering better and more expensive services for the treatment of previously untreated or complex diseases, so these improvements trigger the amount of HE-PC to be high as well. Grossman [4] argues that as the income of individuals increases, the health sector tends to invest more in health services and believes that improved health services will help them gain more wealth in the future [5]. Another factor affecting the HE-PC is the aging criterion. Some studies have argued that people want to live longer spend more money on health care. People's life expectancy is very long in countries where the amount of HE-PC is high [6]. We can emphasize that there is a strong correlation between these two variables. Thus, the demographic (or aging) component refers to the natural demographic change of the population over time in a country in the amount of HE [7]. Furthermore, the need of healthcare resources for healthcare systems of countries influences HE-PC directly or indirectly [8]. In economic growth [9], the production of health services can be depicted as a function of labor and capital. Health resources include doctors, nurses, assistant health workers, health facilities, beds and medical equipment. Number of hospital beds, number of doctors, number of nurses per 1000 people, etc., indicators, such as the amount of HE PC, continue to be used to measure the development of healthcare systems [10]. In summary, we clearly understand that the change in the amount of HE-PC by country tends to be linked to many factors, including health policy [11].

It is inevitable to use statistical approach in researches related to health economics in the literature. In particular, generalized linear models have been used as traditional methods to reduce the deviation or skewness of the data used [12]. The method utilized in this study involved investigation of the behavior of the data on a line (linear or nonlinear) and then formulation of the most appropriate equations. Besides, we aimed to minimize the standard error of the mean level in order to ensure that the results obtained for estimation were consistent with the data used.

In this study, HE PC of OECD countries were evaluated for a wide range (2000-2017) and possible HE PC were estimated for the next eight years [13], [14]. The factors such as gross domestic product, gross domestic product per capita, population, infrastructure of healthcare systems, the resources of healthcare, life expectancy, etc. affecting the HEPC response variable were not taken into consideration for this research. An analysis method was used to compare the actual performance and predicted values using the trend line of economic performances in terms of HE PC of OECD members. The basic component was to follow the trend by using historical data [15] that enables a comparison between the estimated and actual data in this methodology [16].

This research consists of four main sections. In the first part, the importance of HE PC for OECD members were emphasized. The data was gathered, and the method developed was explained for calculating the amount of the HE PC for coming years in the second part of the study. The third part of the study was the calculation of the the amount of the HE PC for the next

8 years through the estimation series. A general interpretation of the study was given in the last part of the study.

2. METHOD

Estimation series method derived by trend-line equations was used to make any predictions for the future years for the methodology in the present research. Trend-line is a line drawn in a graph that helps identify future trends (or trading decisions) by determining the trend based on data points. Trend-lines help to reach a conclusion by using input (independent variable) and output (dependent variable) values to make decisions for the future. Trend-lines are a technical analysis tool used to define the line and ensure its reliability. It is a line drawn to ensure that the trend continues to the future by calculating the distances from the data to the future. Trend lines were expressed on the x, y plot of the line best well-matched (optimal line) to the data by researchers.

For this study, estimation series method has been developed by using the HE PC data produced in previous years in order to estimate the amount of HE PC that OECD members will allocate the budget of per patient for the coming years [13], [14]. Trend-line equations have been derived for the HE PC data. During this period, we assumed that there were no economic crises or fluctuations in exchange rates for this research. The average amount of HE PC by OECD countries between the years of 2000 and 2017 was shown in

Figure 1.

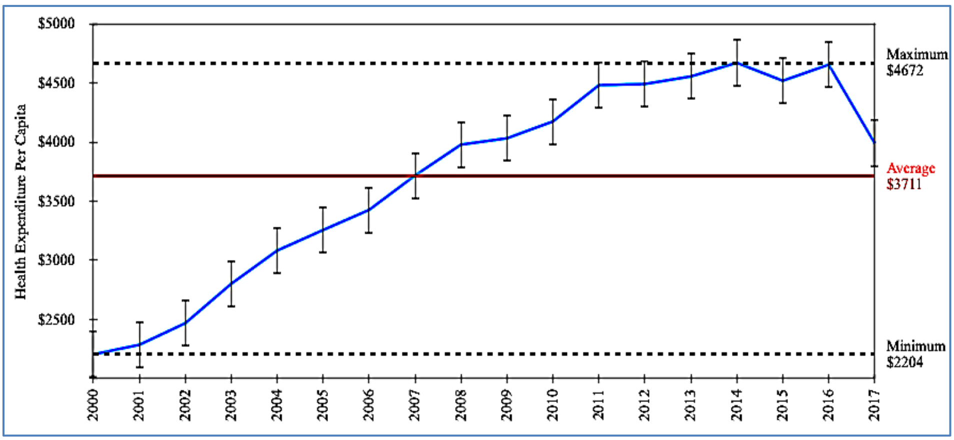

Figure 1. The amount of HE PC by OECD countries by years

The standard error of the mean refers to the distribution and variation in the distribution of sample data. In a sampling, we can say that the lower the standard error of the mean value of the data, the more consistent the spread in the data. Therefore, linear and non-linear equations were derived to minimize the standard error of the mean value in this study.

When OECD countries were compared among themselves for the amount of HE PC, significant difference can be seen for some countries. In this study, averages HE PC were evaluated as single data for each year for all OECD countries.

Figure 1 shows that there was a regular increase in the average HE PC between 2000 and 2017, with the minimum value being seen for the year 2000 where the maximum value was seen for 2014. However, a rapid decreasing in the amount of HE PC was observed for 2015, then this amount rose to the nearly maximum value 2016 again. For 2017, with a dramatic decrease, this amount returns to 2009, the year of the global economic crisis. Despite the changes seen after 2014, HE PC for OECD countries increased from \$2,204 to \$4,672 for this period. The average of HE PC was calculated as \$3711 and nearly greater 1.7 times to the minimum value. As a result, we can emphasize that OECD countries allocate extra budgets for the healthcare systems.

The eight different types of equations have been formulated to calculate the amount of the HE PC for the future. Two parameters were used in the equations. The variable of y (dependent or response variable) represents the amount of the HE PC for the future and the variable of x (independent or input variable) symbolizes the amount of the HE PC generated in the coming years of the OECD members.

In this study, the distribution of the data was observed by making the graphical representation of the HE PC data. Graphical representation was made by considering eight different distribution types. Firstly, the distribution of the data on a linear was shown in

Figure 2 in order to express the data as linear regression.

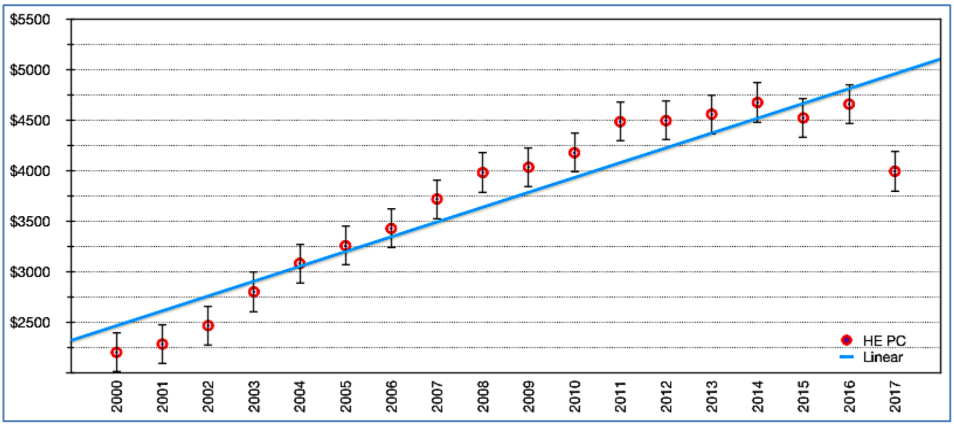

Figure 2. Data of HE PC on linear line

The linear equation developed to generate an estimate of the amount of HE PC generated for the coming years is formulated as follows:

$$y = 146.36x + 2320.40 \quad (1)$$

We created with a quadratic term equation with the second order coefficient among polynomial behavior equations. We can assume that the so-called polinomial equations start with second order equations. In this equation, the independent variable was multiplied by itself. The distances of the data to the nonlinear line were shown in

Figure 3 to formulate the developed quadratic equation for this research.

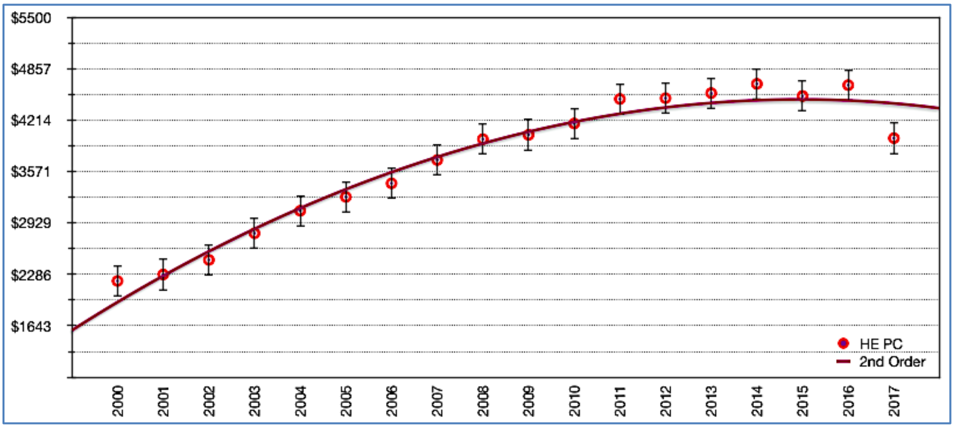

Figure 3. The plot formed according to the quadratic equation

The following equations represent nonlinear equations for the estimation of the amount of HE PC for future years. The second-order equation was formulated as follows:

$$y = -11.597x^2 + 366.71x + 1585.90 \quad (2)$$

Equations where the independent variable has a maximum of 3 roots are expressed as third order equations or cubic equations. These equations allow the data to have more curves than the second order equation considering the distance to the data. The plot of the HE PC data according to the third order equation was clearly indicated in Figure 5.

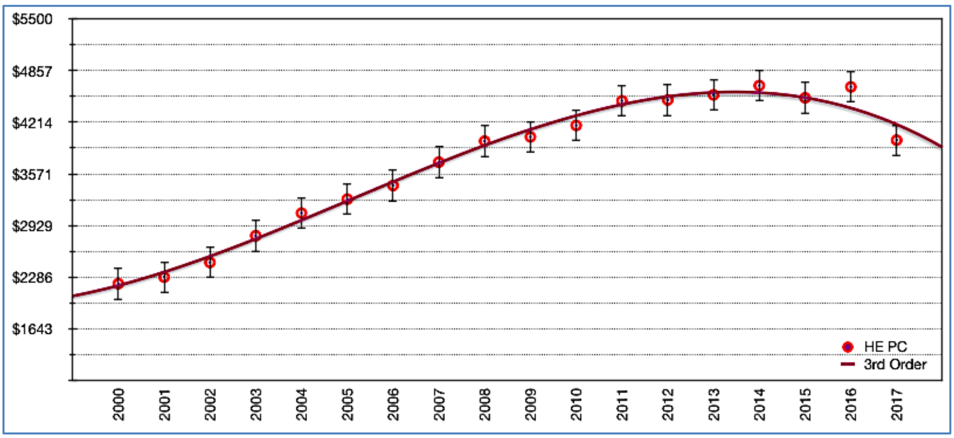

Figure 4. The plot of the data according to the 3^{rd} order equation

The third-order equation was developed as follows:

$$y = -1.162x^3 + 21.52x^2 + 108.17x + 2049.60 \quad (3)$$

The number of degrees or roots of the independent variables of the equations that are created to have more points on the line increases. The plot drawn according to the fourth order equation was closer to the data than the third order derived equation in Figure 5.

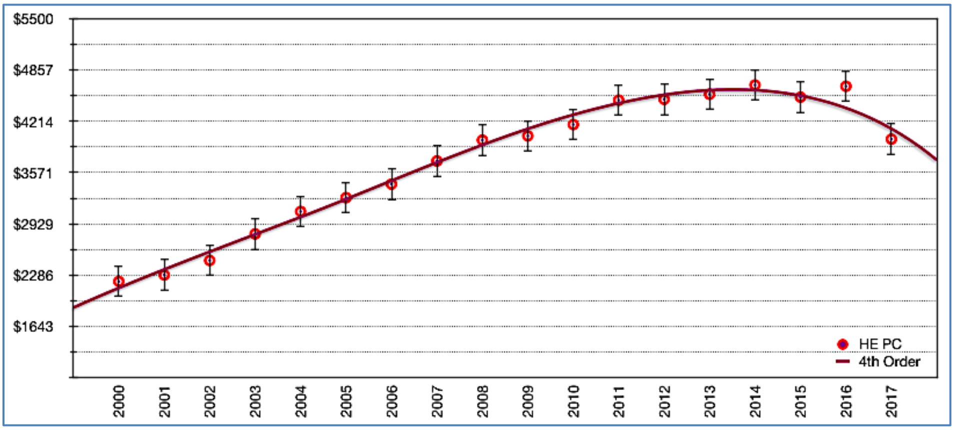

Figure 5. The plot of the data according to the 4th order equation

The fourth-order equation was generated as follows:

$$y = -0.0694x^4 + 1.474x^3 - 11.292x^2 + 255.78x + 1875.60 \quad (4)$$

The equation where all the remaining data is located on a line was expressed by the equation derived from the fifth order equation. In this way, it is ensured that the data is closer to a line so that the values of the standard error of the mean in the data used were at a minimum level. The plot obtained according to the fifth order equation was illustrated in Figure 6. Further equations such as 6th order, 7th order, … etc. were not formed due to the fact that there was no change in the distances of the plots formed by the equations obtained after the 5th order to the data.

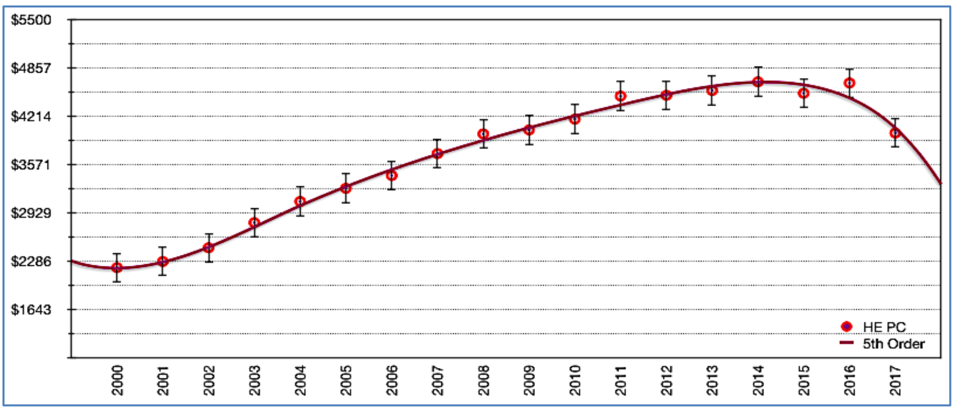

Figure 6. The plot of the data according to the 5th order equation

The fifth-order equation was established as follows:

$$y = -0.026x^5 + 1.1672x^4 - 19.729x^3 + 146.58x^2 - 222.53x + 2292.70 \quad (5)$$

In the exponential function which is one of the most important functions in mathematics, the independent variable is allowed to be the exponent. Such functions are used for the analysis of the easiest dynamic procedures. In order to express the distribution of the data exponentially, the position of the data on the nonlinear line showing the exponential distribution is shown in Figure 7.

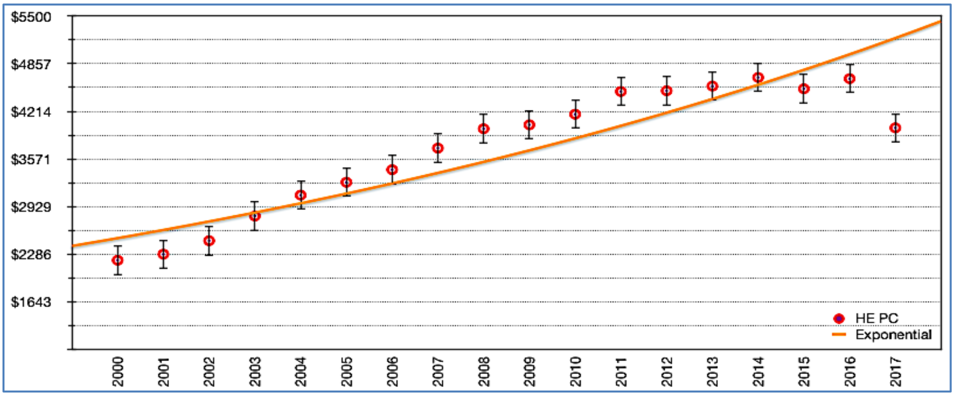

Figure 7. The exponential distribution of data on nonlinear line

The nonlinear equation with exponential distribution has been formed as follows:

$$y = 2396.2e^{0.0431x} \quad (6)$$

Logarithmic equations are explained as inverse of exponential functions. Generally, logarithmic functions are of great benefit in the analysis of very large numbers of data. The visuality of the curve drawn according to the logarithmic function was shown in Figure 8 in order to represent the HE PC data by logarithmic function. In case of rapid increase or decrease in the data, the most appropriate line can be expressed logarithmically. It can cover both positive and negative numbers in the curves of the logarithmic function.

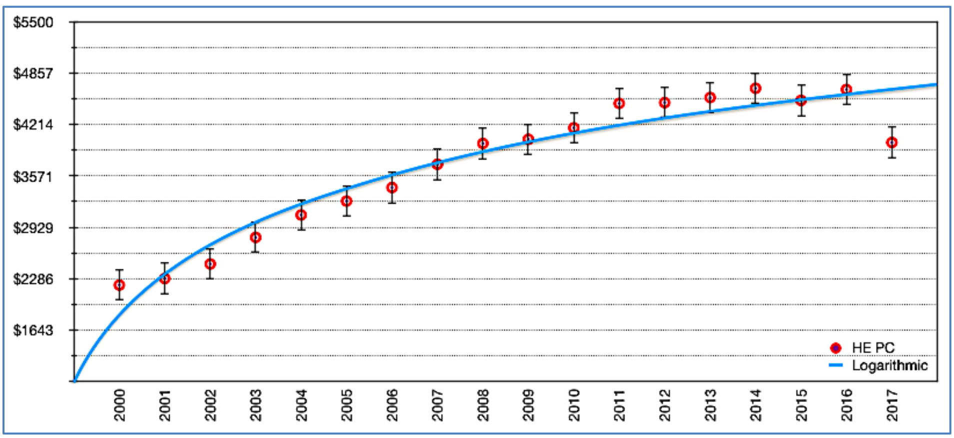

Figure 8. Logarithmic distribution of data on nonlinear line

The logarithmic equation has been created as follows:

$$y = 1001.41 \ln(x) + 1686.00 \quad (7)$$

An appropriate arc is plotted to show the data more symmetrically to reveal the power trendline. Generally, the power trendline method is used for values that increase (very rarely decreasing values) to a certain percentage. The expression of HEPC data for OECD countries according to Power Trend-line is shown in Figure 9.

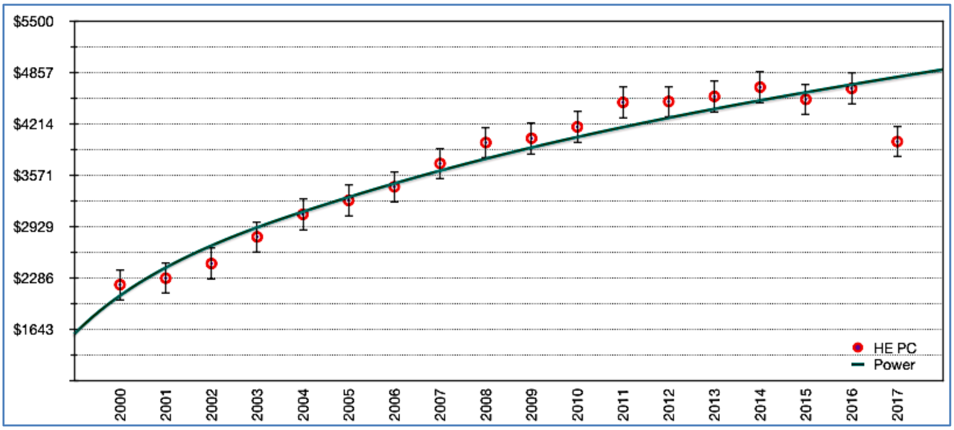

Figure 9. Power trend-line of data

The power equation was developed as follows:

$$y = 1953.1x^{0,3035} \tag{8}$$

Some equations have been developed for the amount of the HE PC that is likely to be purchased by OECD members for the future years. We can assume that the accuracy of the data to be obtained from these equations depends on the degree of reliability of the equations. Reliability should be considered for the methods used in future studies. Reliability is defined as the degree to which stable and consistent results are obtained for the future as a result of an analysis. The high R-squared means that the data used corresponds fully with the trend line. Each linear or non-linear equation derived has a degree of reliability. However, after the fifth degree (for polynomial equations), the values obtained from the reliability degrees of the equations are obtained as constant. Therefore, the fifth order equation which has the highest degree of reliability was terminated for this study. In short, linear, logarithmic, exponential, and power equations, except the first, second, third, fourth, and fifth order equations, have the same degree of reliability, so no other equations are derived from these eight equations. It should be emphasized that these assumptions will only be inadequate by indexing this criterion. Because, the high degree of reliability and the amount of the HE PC in the next years to show the accurate proportion of the error should be avoided (See Figure 10).

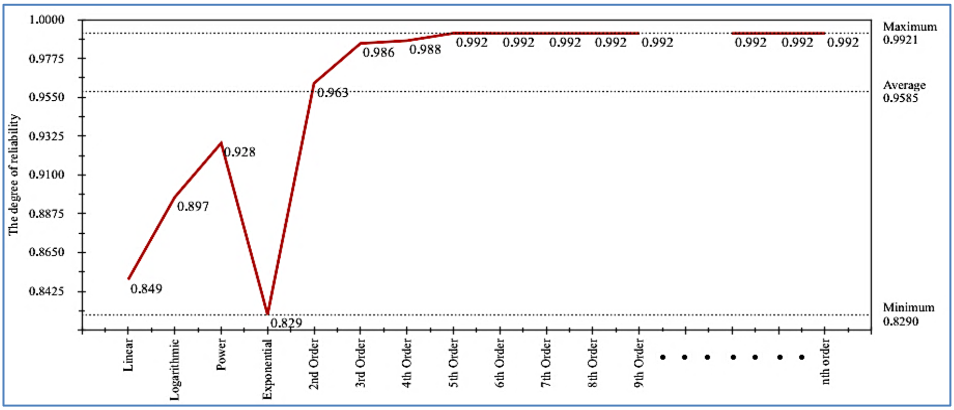

Figure 10. The degree of reliability of the generalized equations for HE PC

The reliability degrees of the generated equations given in Figure 10 were examined. It was seen that the average was calculated 0.9585 (the average value of the eight equations was computed 0.929) and this coincides with the reliability degree obtained for the power equation. The reliability degrees obtained for the second and fifth order equations were above the average, which means that the nonlinear equations developed in the HE PC estimation for future were more reliable. While the 0.9921 value obtained for the fifth-degree equation among these equations was the maximum reliability degree, the minimum value at 0.8290 was obtained for the exponential equation among eight different equations types.

There was a prerequisite to be added to the formulas for the years. The formula that will be used to calculate the amount of the HE PC for the following years was explained as follows:

$$y_i = \frac{y}{(R^2)}, i = \{types\ of\ equations) \tag{9}$$

where, y_i represents the output of the specified equations, and the value of R^2 signifies the degree of reliability for equations, respectively. In the next part of the study, the data related to the amount of the HE PC for the next years was shared with the equations.

3. RESULTS

Datasets were used to evaluate the accuracy of HE PC estimation of OECD members from 2000 to 2017 shared online by OECD DATA in this study. The y-axis value ranges for all trend-lines in the charts set the maximum and minimum limits of the amount of HE PC in the specified years. The distances of the data to the lines were taken into consideration in the formation of the estimation equations of the HE PC response variable. Thus, we aimed to minimize the standard error of the mean level in order to ensure that the results obtained for estimation were consistent in the data used. Statistically, the average value of the data indicates the region where the data are accumulated (normal distribution feature) and that near future data will appear in the future. The standard error of the mean, standard deviation or variance values show the deviations of the data at the mean value point. It is desirable that these values are small. The values of these data should be small in order to decrease the deviation or variability in the data and to gain consistency in the data obtained for the future.

Forecasting calculations about HE PC cover the years 2018-2025. The data regarding the amount of the HE PC production were explained in

Table 1 in detail. The average amount of the HE PC was calculated as $4,616.62, which we can argue as a decrease in the budget allocated for the amount of the HE PC. Standard deviations of all estimated data of HE PC were calculated as \$367.76. This value indicates that the fluctuation in forecast data of HE PC for the future was only 7.96%.

Table 1. Results of forecasting data according to equations

Year	Linear	Logarithmic	2nd Order	3rd Order	4th Order	5th Order	Power	Exponential
2018	\$4,283.10	\$4,332.58	\$4,106.47	\$4,069.21	\$3,930.13	\$3,934.27	\$4,098.28	\$4,260.21
2019	\$4,455.43	\$4,450.20	\$4,260.41	\$4,279.10	\$4,134.64	\$4,100.80	\$4,231.45	\$4,447.84
2020	\$4,627.76	\$4,556.61	\$4,390.47	\$4,461.29	\$4,321.38	\$4,257.03	\$4,355.64	\$4,643.74
2021	\$4,800.09	\$4,653.75	\$4,496.66	\$4,608.54	\$4,481.58	\$4,406.39	\$4,472.20	\$4,848.26
2022	\$4,972.42	\$4,743.11	\$4,578.97	\$4,713.61	\$4,604.82	\$4,545.91	\$4,582.17	\$5,061.79
2023	\$5,144.75	\$4,825.84	\$4,637.41	\$4,769.26	\$4,678.96	\$4,663.15	\$4,686.40	\$5,284.72
2024	\$5,317.08	\$4,902.86	\$4,671.97	\$4,768.25	\$4,690.20	\$4,733.02	\$4,785.56	\$5,517.47
2025	\$5,489.41	\$4,974.91	\$4,682.66	\$4,703.34	\$4,623.03	\$4,714.60	\$4,880.22	\$5,760.47

The minimum value of the amount of the HE PC was \$3,930.13 with the 4th order equation for the year 2018 and the highest amount was calculated as \$5,760.47 for the year 2025 with the equation of exponential distribution. The highest standard deviation values belong to linear and exponential equations. Standard deviation values of other equations are close to each other. We also observed this situation for the variance and standard error of the mean values of the equations (see Table 2).

Table 2. Descriptive statistics of forecast data

Variable	Mean	SE Mean	StDev	Variance	Minimum	Maximum
Linear	4886,26	149,24	422,12	178185,77	4283,10	5489,41
Logarithmic	4679,98	79,21	224,03	50187,64	4332,58	4974,91
2nd Order	4478,13	74,22	209,93	44072,30	4106,47	4682,66
3rd Order	4546,58	90,80	256,83	65962,54	4069,21	4769,26
4th Order	4433,09	99,01	280,05	78428,22	3930,13	4690,20
5th Order	4419,40	105,59	298,64	89187,11	3934,27	4733,02
Power	4511,49	96,52	272,99	74523,31	4098,28	4880,22
Exponential	4978,06	185,61	524,98	275605,63	4260,21	5760,47

Note: StDev-standard deviation; SE Mean-standard error of the mean

The comparison of the results obtained with the equations developed for HE PC was shown in detail in Figure 11. According to linear, exponential and 3rd order equations, there will be little change in the amount of the HE PC for the next eight years and horizontal trends was observed by the rest of predictor equations.

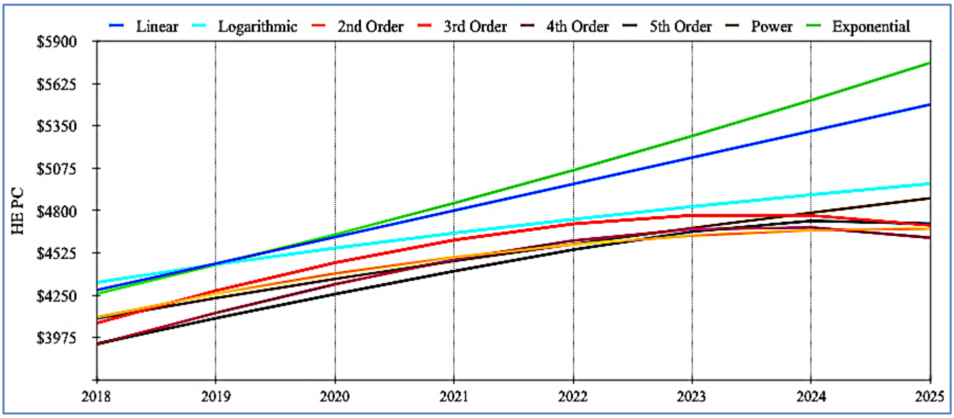

Figure 11. Trends of estimation series equations by years

The trend of HE PC for the members of OECD during the period 2018-2025 was estimated basing on the data of the average values of HE PC from 2000 to 2017. A trend line analysis by generating one linear equation and seven non-linear equations was carried out for this research. The results obtained with the fifth-order equation which shows the highest degree of reliability with 0.992, indicates that HE PC will not be too larger than the highest value shown in 2014 because of the decreasing value in the last year, namely 2017. However, this trend of the rising of HE PC will be continued in the 2018-2025 period according to this equation. Although the amount of HEPC increased continuously until 2024, we observed a horizontal trend (or slight decreasing) after 2024 according to the second, third and fourth, power order equations.

Values in a forecast process are based on remnants from previous periods. Thus, the model created takes into account each point in time to estimate the next y value. A difference occurs between the predicted value and the actual values. These differences cause an error in the forecast values. This error is often referred to as the mean absolute percent error (MAPE). Thus, the suitability of the model for testing is tested. MAPE in the estimation of HE PC were observed 7% for linear, while the MAPE for polynomial, exponential, power and logarithmic equations were estimated 3.4% in this study. These rates represent the deviations or errors (decrease or increase) as percentage in the estimates.

The amount of HE PC shared by OECD Data was calculated $3992 for 2018. Consistency ratios of this amount according to the linear, logarithmic, 2nd order, 3rd order, 4th order, 5th order, power, and exponential, equations developed for this study are 93.20 % (The rate of deviation was 0.0831), 92.14 % (The rate of deviation was 0.0244), 97.23 % (The rate of deviation was 0.0093), 98.11 % (The rate of deviation was 0.0049), 98.43 % (The rate of deviation was 0.0037), 98.55 % (The rate of deviation was 0.0065), 97.41 % (The rate of deviation was 0.0541), and 93.71 % (The rate of deviation was 0.1081) respectively. The resulting reliability difference values were only calculated between 0,0037 (0.37 %) and 0,1081 (10.81 %). It was observed that there was a considerable difference between the results obtained with this study and the OECD data. By comparing the results, the lowest (most consistent result) difference was obtained by the fourth order equation. Conversely, the highest level of difference was obtained by the Power-order equation. We emphasized that the method developed for this study was very consistent and the results were very accurate for the future.

Predictive equations HE PC values were found to be suitable for use as a consistent analysis tool for future outcomes. It can be emphasized that there is no drawback in the use of estimation equations for other indicators in the field of healthcare, as only the use for HE PC was verified in this study.

This study has several limitations. For example, the health system type of a country could not be taken into consideration in this study due to the lack of information on this subject. Another limitation was that the data were relatively short-term. We have proved that one of the most important economic dimensions is HE PC and is a good predictive variable for high quality healthcare. The economic development of a country also represents the size and development of the health economy. It is not surprising that advanced health systems exist in economically developing countries. The fact that people have a high economic advantage in the field of health has paved the way to receive a quality service. It is inevitable that large investments in the field of health will be made economically by the state or private enterprise in order to create quality health services. Another important issue is the type of health system as well as its economic and technological development in health systems. In other words, it is important whether the state's health systems have a social or non-social health system. In countries with social health systems, the majority of health spending is covered by the state. However, it is understood that countries with social health systems fall behind the non-social health systems both economically and technologically. Since there are a limited number of studies on this subject (the first study on this topic), this study is very important for future studies to calculate the HE PC of all countries.

4. CONCLUSIONS

The amount of the HE PC is considered to be the indicator of having a strong healthcare system worldwide. The aim of this study was to reveal the future situation of HE PC of OECD countries. A series of forecasts for the next eight years have been formed by using the amount of the HE PC data of OECD members covering the years 2000-2017. Assuming that there will be no economic crisis and no significant fluctuations in exchange rates between 2018-2025, we applied the trend-line analysis to estimate HE PC so that trends in the near future give an idea for financial sustainability. Eight different equations, one linear and seven non-linear, were obtained to forecast the amount of HE PC for the future. The data was generated from the reliability degrees of these equations in order to compare the amount of the HE PC data for the future. According to the results obtained with the fifth order equation showing the highest degree of reliability with 0.992, HE PC was estimated to be no more than the maximum value reached in 2014. Notice that, such estimations were based on available data, thus, the sharp decline in 2017 may have an effect on. The minimum value of the amount of the HE PC was \$3,930.13 with the 4^{th} order equation for the year 2018 and the highest amount was calculated as \$5,760.47 for the year 2025 with the equation of exponential distribution. The average amount of the HE PC was calculated as \$4,616.62 which we can argue as a decrease in the budget allocated for HE PC. Although there are fluctuations in the amount of the HE PC for the future, the standard deviations in all of this data were found to be 7.96%, corresponding to \$ 367.76. The fluctuations in the amount of the HE PC depend on many factors. These factors can be supported by a more detailed research to identify and calculate their impact on HE-PC.

In future studies, we propose this method to researchers to examine the factors affecting the health economy for countries with a social and non-social health system, and to show differences in terms of costs and expenditures of healthcare.

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