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The relationship between life expectancy at birth and health expenditures estimated by a cross-country and time-series analysis

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Abstract

In the last years, most countries experienced improved health outcomes as longevity increased steadily and infant mortality rate decreased, along with a growth of the health expenditures. The paper aims to analyze the relationship between the dynamics of the inputs and the outputs of health care systems. The input of the health care system is expressed by health care expenditures per capita (current US$) and the output of the health care systems is expressed by life expectancy at birth (years). The data are collected for 175 world countries, grouped according to the geographic position and income level, over 16 years (1995-2010). We apply a panel data analysis to estimate life expectancy by a function of health expenditures. The obtained results show a significant relationship between health expenditures and life expectancy. Country effects are significant and show the existence of important differences among the countries.

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Keywords: health system; income; geographic region; panel data; country-effects.

1. Introduction

The health of the population is under the impact of both the type of health systems and of their resources. The relationship between resources and outcomes is important for assessing if a country has a performing health system. A country has a health system with a better performance than another country, if, for the same level of resources, it generates better health outcomes, or if it generates the same outcomes but with fewer resources (Elola et al., 1995). Health systems are financed either through taxes, in the case of healthcare

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services owned by the state (national health services), or through income-related social contributions (social security systems) (Elola et al., 1995; Paris et al., 2010). In countries with high income per capita, the contributions to social security are important and sustain in a high extent the financing of the health system.

This study aims to analyze the relationship between the dynamics of the inputs and the outputs of health care systems. With the purpose of identifying the influence of health expenditures on life expectancy, we apply panel data analysis on a sample of countries grouped according to the geographic region and the income level per capita. To estimate the relationship between the two variables, we chose a fixed-effects model on country-level data covering the period 1995-2010 for different groups of countries.

The paper begins by a general reference to previous studies on the relationship between health outcomes and health resources. Then, it lays out the variables and the sample of countries, as well as the fixed effects regression approach. Finally, the main empirical results are presented and the final conclusions are drawn.

2. Literature review

The resources of health systems are measured by several indicators such as health expenditures (total expenditures on health per capita, health expenditure as % of GDP, % of public expenditure in total health expenditure), number of physicians, number of hospital beds, number of computed tomography scanners (Or, 2000; Ramesh and Mirmirani, 2007, Baltagi and Moscone, 2010). The indicator considered in this study for measuring the health input is total health expenditures per capita.

The output of the health systems is expressed either by longevity indicators such as life expectancy (life expectancy at birth, life expectancy at 65 years, healthy life expectancy) for total population and/or by gender, or by mortality indicators (mortality rate, infant mortality rate, potential years of life lost). These indicators are considered good proxies for measuring the health status of a population (Show et al, 2002; Cutler et al., 2006; Or, 2000; Poças and Soukiazis, 2010). The greater the life expectancy in one country, the healthier its population is (Jen et al., 2010). In the paper, life expectancy is considered for assessing the health status.

Previous studies that investigated the relationship between health resources and health outcomes are diverse in what concerns the analysed indicators, the model approach, and the countries studied. A review of the literature in this field was done by Nixon and Ulmann (2006). The majority of these studies analyzed panel data for developed countries, such as the US (Lichternberg, 2000), Canada (Crémieux et al., 2005) or the OECD countries (Hitiris and Posnet, 1992; Show et al., 2005), though some recent papers are focused on developing and less developed countries (Bayati et al., 2013). It has been found that health expenditures have a significant positive impact on life expectancy and a significant negative impact on mortality rate.

3. Data and method

3.1. Data

In this paper, we study the relationship between health expenditures and health outcomes. One of the indicators used to summarize the health expenditures is the total health expenditure. The total health expenditure is the sum of general government expenditure on health and private expenditure on health in a given year (The World Bank Data Indicators, 2013). In this analysis, we considered the health care expenditures per capita (current US$) as the explanatory variable.

In order to measure the outcomes of a health system we used life expectancy. Life expectancy at certain ages represents the mean number of years still to be lived by a person who has reached a certain exact age, if subjected throughout the rest of his or her life to the current mortality conditions (age-specific probabilities of dying) (Chiang, 1984). We analysed life expectancy at birth (years) as the dependent variable.

The data are collected for 175 world countries over 16 years (1995-2010). The countries are grouped according to the geographic region (World Health Organization classification) and the income group (World Bank classification). The data are saved from World Bank Indicators Database.

3.2. Method

The level and the variation of health expenditures per capita and of life expectancy at birth, by groups of countries, in 1995 and 2010 (the first and the last year of the period) are analysed using the box plots.

The influence of health expenditures on health outcomes, namely on life expectancy at birth, for a group of 175 countries in the world, in each year during the period 1995-2010, is estimated by a fixed effects model. This particular regression model explains the variation in life expectancy, the dependent variable, as a function of explanatory variables, such as health expenditures. The estimated effect of health expenditures on life expectancy is a net effect and is expressed by the β_1 coefficient, and the influence of country specific characteristics is expressed by the γ coefficients.

The country fixed effects model used in the study is the following:

$$LE_{(it)} = \beta_0 + \beta_1 HE_{(it)} + \gamma_1 C_1 + \ldots + \gamma_{n-1} C_{n-1} + u_{(it)}$$

Where

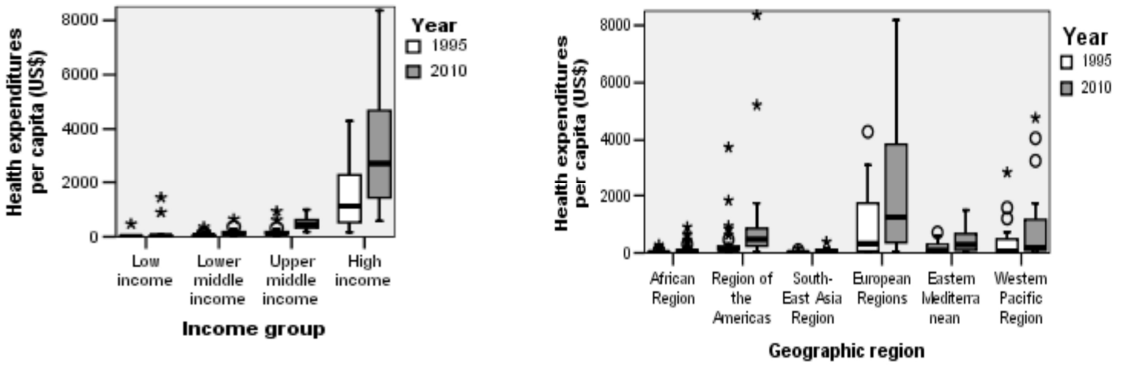
- *LE* is the dependent variable, life expectancy at birth (years);
- *HE* is the explanatory variable, health expenditures;
- *i* represents the country identifier, *i=1, ..., 175*;
- *t* represents the time identifier, *t=1, ...,16*;
- β_0 is the intercept of the fixed effects model with dummy variables;
- β_1 is the coefficient of the explanatory variable (the coefficient is common for all the countries);
- $C_1, C_2, \ldots, C_{n-1}$ are the binary variables *Country*. The number of *Country* variables included in the model is equal to the number of countries minus 1;
- γ represents the coefficients of the binary variables *Country*;
- *u* is the error term of mean equal to 0.

The estimation of the fixed effects model is done using the SAS 9.2 and SPSS 19.0 statistical software.

4. Results

In the last years, health expenditures increased (Fig. 1). The growth of health expenditures is due to several factors such as population ageing, medical technology and improvements in life standards. The most significant increase of health expenditures per capita is observed for the developed countries, namely countries with high Gross National Income (GNI) per capita (Fig. 1(a)). The variation of health expenditures per capita is also more important among the developed countries than among developing and less developed countries, and this difference is growing in time (Fig. 1(a)). Health expenditures per capita are particularly high, in 2010, in USA (8361.73 US $), Luxemburg (8181.10 US $), Norway (8091.29 US $), and Switzerland (7812.22 US $). In the less developed countries, health expenditures per capita are low, especially in Eritrea (11.90 US $), Ethiopia (15.71 S $), and Democratic Republic of Congo (15.75US $). When comparing different groups of countries defined by geographic region, it can be seen that the in the European region, where there is a high number of developed countries, the level of health expenditures is the highest compared to the other regions. In the same time, in European region there are the largest differences in health expenditures (Fig. 1(b)). The two developed

countries USA and Canada are the extreme high values for health expenditures in the Region of the Americas, while Australia, Japan and New Zeeland are the outliers of the Western Pacific Regions.

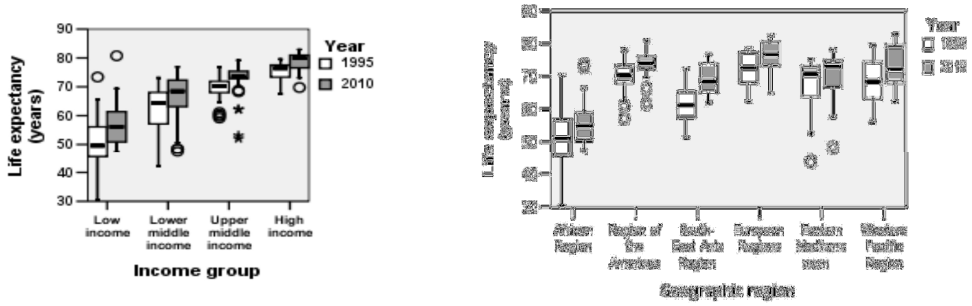


(a) (b)

Fig. 1. Health expenditures variation among world countries, by income group (a) and by geographic region (b), in 1995 and 2010

Source: own computation in SPSS 19.0

The improved health outcomes are highlighted by the increased longevity. Life expectancy is higher in developed countries than in developing and less developed countries (Fig. 2(a)).



(a) (b)

Fig. 2. Life expectancy variation among world countries by income group (a) and by geographic region (b), in 1995 and 2010

Source: own computation in SPSS 19.0

The variation across countries is wider in less developed countries but with a tendency toward better convergence. The highest longevity is noticed for the populations of the European countries (Fig. 2(b)). The largest growth of life expectancy during the observed 15 years is observed in the South-East Asia Region

countries. The countries of the Region of Americas are the most homogeneous with respect to life expectancy, though Bolivia and Haiti have lower values compared to the other countries in the region. Population of the African countries has the lowest longevity, while Cape Verde is an outlier with high life expectancy.

There are several factors that explain life expectancy variation, such as health expenditures, access to healthcare services, individuals' education, income distribution, and life style (smoking and alcohol consumption) (Joumard I. *et al.*, 2008). These factors have important values in the developed countries and their effect is direct on life expectancy.

The fixed effects model is applied separately by group of countries defined according to the income level and geographic region. The results are presented in Tables 1 and 2.

Table 1 presents the main results obtained for the analysis of life expectancy as a function of health expenditure for the four groups of countries: low income, lower middle income, upper middle income, and high income. The estimates of the parameters β_0 and β_1 with standard errors in parentheses and the R-Square values are shown.

It is apparent from Table 1 that life expectancy is explained by health expenditures, for all the four groups of countries the values of R-Square are large. Also, life expectancy is different among the four groups of countries (see intercepts). The values of the regression coefficients associated to health expenditures are positive, and there is a significant positive relationship between the two variables for all the four groups of countries. The highest effect of health expenditures on health outcomes is obtained for the lower middle income group, while the smallest effect is obtained for the high income group.

Table 1. Parameter estimates for fixed effects models estimated for groups of countries, defined by income level per capita, over the period 1995-2010

Variable	Low income	Lower middle income	Upper middle income	High income
Intercept	48.3339***	43.23285***	71.62015***	71.77245***
	(0.6347)	(0.4255)	(0.3523)	(0.3074)
Health expenditures	0.006661***	0.022537***	0.004904***	0.000932***
	(0.00137)	(0.00153)	(0.000353)	(0.000038)
N	35	52	45	43
R-Square	0.9072	0.9599	0.9430	0.9261
Number. of significant Fixed Effects (Cross Sectional Effects)	24	51	31	38
F Test for No Fixed Effects	121.46***	318.26***	239.95***	107.00***

Note: *** p<0.0001

Source: own computation in SAS 9.2

The number of fixed effects (γ – the coefficients of the binary variables) is equal to the number of countries minus 1. The fixed effects correspond to the individual differences between countries, therefore the higher the number of significant fixed effects, the greater the heterogeneity among countries. The number of significant country effects is presented in Table 1.

It can be seen that low income countries and upper middle income countries are the most homogeneous, as the number of significant fixed effects is smaller compared to the other groups: 24 out of 34 fixed effects (that is 70.59% significant country differences) and 31 out of 44 (70.45%) respectively. Countries with lower middle income are the most heterogeneous. The number of significant fixed effects shows the existence of significant differences among countries grouped according to their development level.

The hypothesis that all fixed effects are all equal to 0 is rejected (large values for the F test), therefore it is correct to include fixed effects in the model. The estimates of the country-effects show differences and similarities among the countries in each group in relation to the reference country. For the upper middle income group, Romania is chosen as the reference country. Countries with similar estimated life expectancies to Romania are Argentina, Bulgaria, China, Poland, Turkey, Macedonia, Jordan, Libya, Malaysia, Grenada, Tunisia, St. Vincent, and Venezuela. The developing countries that have significant higher estimated life expectancy compared to Romania are Costa Rica, Cuba, and Chile.

The results obtained for the estimation of the relationship between life expectancy and health expenditures for the six geographic regions are shown in Table 2. The coefficients of the explanatory variable are significant for all the six groups. The highest effect of health expenditure on life expectancy is observed for the countries of the South-East Asia Region, while the smallest effect is seen for the European Regions countries.

Table 2. Parameter estimates for fixed effects models estimated for groups of countries, defined by geographic region, over the period 1995-2010

Variables	African Region	Region of the Americas	South-East Asia Region	European Regions	Eastern Mediterranean Region	Western Pacific Region
Intercept	43.90167***	72.77935***	55.41139***	67.02547***	61.1469***	72.49308***
	(0.6337)	(0.3210)	(0.5694)	(0.2675)	(0.3356)	(0.3865)
Health expenditures	0.004369*	0.001277***	0.045659***	0.000963***	0.002661***	0.001908***
	(0.00155)	(0.000153)	(0.00497)	(0.000051)	(0.000472)	(0.000261)
N	44	33	10	48	20	20
R-Square	0.8897	0.9181	0.8629	0.9565	0.9727	0.9514
Number. of significant Fixed Effects (Cross Sectional Effects)	41	28	9	45	19	17
F Test for No Fixed Effects	114.87***	139.57***	66.77***	147.06***	400.07***	136.93***

Note: *** p<0.0001, **p<0.001, *p<0.01

Source: own computation in SAS 9.2

The F test shows that country effects in the models for data grouped by geographic regions are significant. The large values obtained for the F test allows us to reject the null hypothesis that all coefficients of the country binary variables are all equal to 0.

The number of significant country effects is high for all the six samples, therefore the regions are characterized by important heterogeneity. In the European Region group, the reference country is Romania, consequently the fixed effects represents the differences in life expectancy between each country within the region and Romania. From the 47 country effects, 45 effects are significant and the highest estimated differences from the reference country are noticed for Italy, Israel, Cyprus, and Greece. For Moldova and Azerbaijan there are no significant differences compared to Romania.

5. Conclusions

This paper has investigated the influence of health resources on health outcomes for groups of countries defined according to the income level and geographic position. In this investigation, the aim was to assess the

relationship between life expectancy at birth and health expenditure per capita by groups of countries with different development levels and geographic positions.

The results of the panel data analysis using the fixed effects model revealed that inequalities in health care expenditures explain the different outcomes of health care systems, by groups of countries defined according to income level and geographic region. The present research confirms the previous findings on the relationship between health status and health expenditures.

One obvious finding that emerges from this study is that, for developed countries, health expenditures per capita increased significantly along with an increase in longevity, the European countries facing the highest longevity.

The results of this research show that the variation of health expenditures per capita is also more important among the developed and developing or less developed countries, and this difference is growing in time.

The current study has only examined the effect of one determinant factor, namely health expenditure, on health status of a population. The choice of one factor was done due to the reduced availability of data for a big sample of countries. However, other factors related to individuals' life style, education, and income should be considered in a future research. Further work also needs to be done to find better indicators that measure the health status of the population. Therefore, other indicators such as healthy life expectancy could be a better alternative.

Taken together, the findings of this study related to the link between the health expenditures and the health status of the population support the idea that health policies should be oriented toward the reduction of health inequalities among the world countries.

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