ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΩΣ

ΤΜΗΜΑ ΟΙΚΟΝΟΜΙΚΗΣ ΕΠΙΣΤΗΜΗΣ

ΠΡΟΓΡΑΜΜΑ ΜΕΤΑΠΤΥΧΙΑΚΩΝ ΣΠΟΥΔΩΝ
«ΟΙΚΟΝΟΜΙΚΑ και ΔΙΟΙΚΗΣΗ της ΥΓΕΙΑΣ»

Δαπάνες για την Υγεία και Δημοσιονομική Βιωσιμότητα: Στοιχεία από τις χώρες του ΟΟΣΑ

Χριστόπουλος Κωνσταντίνος

Διπλωματική Εργασία υποβληθείσα στο Τμήμα Οικονομικής Επιστήμης του Πανεπιστημίου Πειραιώς για την απόκτηση Μεταπτυχιακού Διπλώματος Ειδίκευσης στα Οικονομικά και Διοίκηση της Υγείας

Πειραιάς, 2019

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΩΣ

ΤΜΗΜΑ ΟΙΚΟΝΟΜΙΚΗΣ ΕΠΙΣΤΗΜΗΣ

ΠΡΟΓΡΑΜΜΑ ΜΕΤΑΠΤΥΧΙΑΚΩΝ ΣΠΟΥΔΩΝ
«ΟΙΚΟΝΟΜΙΚΑ και ΔΙΟΙΚΗΣΗ της ΥΓΕΙΑΣ»

Δαπάνες για την Υγεία και Δημοσιονομική Βιωσιμότητα: Στοιχεία από τις χώρες του ΟΟΣΑ

Χριστόπουλος Κωνσταντίνος, Α.Μ.: ΟΔΥ/1651

Επιβλέπων: Ελευθερίου Κωνσταντίνος / Επίκουρος Καθηγητής / Πανεπιστήμιο Πειραιώς

Διπλωματική Εργασία υποβληθείσα στο Τμήμα Οικονομικής Επιστήμης του Πανεπιστημίου Πειραιώς για την απόκτηση Μεταπτυχιακού Διπλώματος Ειδίκευσης στα Οικονομικά και Διοίκηση της Υγείας

Πειραιάς, 2019

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΩΣ

ΤΜΗΜΑ ΟΙΚΟΝΟΜΙΚΗΣ ΕΠΙΣΤΗΜΗΣ

M.Sc. in Health Economics and Management

Health Care Expenditure and Fiscal Sustainability: Evidence from the OECD countries

Christopoulos Konstantinos

Master Thesis submitted to the Department of Economics of the University of Piraeus in partial fulfilment of the requirements for the degree of M.Sc. in Health Economics and Management

Piraeus, Greece, 2019

στην οικογένειά μου

Ευχαριστίες

Θα ήθελα να ευχαριστήσω τον επιβλέποντα καθηγητή μου κ. Κωνσταντίνο Ελευθερίου για τη συμβολή του στο να ξεπεραστούν οι αρκετές δυσκολίες που αντιμετώπισα για την ολοκλήρωση αυτής της εργασίας, καθώς και τον κ. Βασίλη Καταβέλη που ήταν πάντοτε πρόθυμος και διαθέσιμος σε ό,τι τον χρειάστηκα. Επίσης, ευχαριστώ όλους όσους βοήθησαν σε αυτή την προσπάθεια με την στήριξη, καθοδήγηση και υπομονή τους καθώς και τους ανθρώπους στα φόρουμ λογισμικού που είναι πάντα πρόθυμοι να βοηθήσουν χωρίς προσωπικό όφελος οποιονδήποτε αντιμετωπίζει πρόβλημα.

Δαπάνες για την Υγεία και Δημοσιονομική Βιωσιμότητα: Στοιχεία από τις χώρες του ΟΟΣΑ

Σημαντικοί Όροι: Υγεία, δημοσιονομική πολιτική, δαπάνες υγείας, χωρική οικονομετρία

Περίληψη

Οι δαπάνες υγείας προβλέπονται να αυξηθούν ακόμα περισσότερο στα επόμενα χρόνια ασκώντας ακόμα μεγαλύτερες δημοσιονομικές πιέσεις. Σκοπός της παρούσας εργασίας είναι να εξετάσει την επίδραση και τα αποτελέσματα διάχυσης των δαπανών υγείας στην υγεία του πληθυσμού, μετρούμενη με τα Πιθανά Χαμένα Έτη Ζωής (Potential Years of Life Lost) και την οριακή επίπτωση που έχουν στα δημόσια οικονομικά. Χρησιμοποιώντας δεδομένα από 29 χώρες του ΟΟΣΑ για την περίοδο 1990-2017, εφαρμόσαμε μοντέλα χωρικής οικονομετρίας καθώς και ένα μη-χωρικό μοντέλο. Για τον υπολογισμό της οριακής επίπτωσης χρησιμοποιήσαμε το συντελεστή του χωρικού μοντέλου σε ένα αναλυτικό δημοσιονομικό πλαίσιο που περιλάμβανε τα μέσα φορολογικά έσοδα και κόστη για τις κυβερνήσεις. Βρήκαμε μια θετική σχέση μεταξύ δαπανών υγείας και του δείκτη υγείας καθώς και σημαντικά αποτελέσματα διάχυσης τα οποία μεταφράζονται δημοσιονομικά σε $2551.45 έσοδα για κάθε κατά κεφαλήν δαπανηθέν δολάριο.

Health Care Expenditure and Fiscal Sustainability: Evidence from the OECD countries

Keywords: Health, fiscal policy, health spending, spatial econometrics

Abstract

Health care expenditures are expected to challenge the fiscal sustainability even more in the coming years. The purpose of this study is to examine the relationship and spillover effects between the Health Care Expenditures and health measured by the Potential Years of Life Lost and the marginal impact they have on public accounts. Using data from 29 OECD countries during the period 1990-2017, we apply spatial health econometrics models as well as a fixed-effects model. For the calculation of the marginal impact, we used the coefficient of our spatial model into a fiscal analytic framework consisting of averaged tax revenues and costs of the government. We find a positive relationship between Health Care Expenditures and health as well as significant spillover effects which are translated fiscally into $2551.45 revenue for every per capita dollar spent.

Contents

List of Tables

Chapter 1

Introduction

The ever increasing Health Care Expenditures (HCE) pose a burden to governments and tax payers around the world and will continue in doing so in the comings decades. The health spending in 2017 for the OECD countries accounted for the 9% of the GDP on average (OECD, 2017a). According to Burtless (2006) who estimated the current and future tax burdens of four rich OECD countries, the government transfer programs were a major source of income for dependent elderly especially in Germany where the net social transfers of taxes and public health benefits make up 65% of the income of people over the age of 65. In Japan, the demographically oldest OECD country, with a dependency ratio equal to 47 in 2015 (OECD, 2017b), health spending has skyrocketed. The two-thirds of this increase in spending, from 1990 to 2011 was the result of ageing and the rest one-third resulted from the excessive increase in costs. HCE in Japan are predicted to increase even more with the ageing of the population alone raising it by 31% of GDP in the years 2010-30. Moreover, if excessive costs continue to grow at the same rate as in 1990-2011, they will raise this percentage by an additional 2-3 percentage points of GDP. The government will have to increase its transfers considerably in the coming years if this situation does not improve (Nozaki et al., 2017).

There are many studies on the determinants of HCE. According to a literature review done by José J. Martín Martín (2011) on the subject, the main variables responsible for their rise of HCE are income, population ageing, proximity to death and technological advancements and territorial decentralisation. More specifically, a number of studies show the significance of income as a determinant such as the one by Hitiris and Posnett (1992) who states that the GDP plays a significant role as a HCE determinant in developed countries. Baltagi et al. (2017) who also investigated the long-run economic relationship between healthcare expenditure and income on a global scale with the use of data for 167 countries from the years 1995 to 2012, found that health care is considered on a global level a necessity rather than a luxury and also that the position of each country into the distribution of the global income affects the size of their income elasticity, with lower-income countries showing a higher elasticity. Population ageing might not be the main driver of the HCE but its economic effects, based on the notion of age-based dependency[1], will affect the amount of taxes that will fund the pay as you go (PAYGO[2]) pensions Weil (2006). Moreover, it narrows the tax base and widens the fiscal expenditure by reducing labor's quality and productivity, changing the level and structure of the population's consumption, lowering the saving rate, and widening the gap between social security revenue and expenditure, all of which challenge the balance of the fiscal system (Liu and Yang, 2018). Some studies though claim that proximity to death is the main determinant of HCE and not the ageing of the population. In a panel structure cohort study of seven years Howdon and Rice (2018) use administrative data, which contains estimates of inpatient HCE, time-to-death (TTD) and morbidities at the time of an admission, to show that HCE is mainly determined by the proximity to death rather than the age of individuals, and that proximity to death is itself a proxy for morbidity.This conclusion is also confirmed by Layte (2007) who used random effects models in a national panel data survey in Ireland to demonstrate that the expenditures on General Practitioners and hospital services are affected more from the proximity to death rather than age. Another study that shows the decreased role of population ageing and sets technology as the main determinant and morbidity as second, is that of Dormont et al. (2006). How much though is our health affected by this spending and what does this mean for the fiscal sustainability of a country?

The link between health status and increased productivity therefore, more

[1] *The demographic old-age dependency ratio is defined as the number of individuals aged 65 and over per 100 people of working age defined as those aged between 20 and 64 (OECD, 2017b)*

[2] *Financing expenditures with currently available funds*

economic growth has been evident from the early work of Schultz (1961) and Mushkin (1962) and later of Rivera (1999) and Heshmati (2001) who examined also the convergence between countries. This effect is stronger on poor countries (Well, 2007) but its effect on rich countries is not clear for long-term growth (Hartwig, 2010). Gong et al. (2012) also confirms these claims but warns that excessive investment in health may have a negative effect on economic growth. But is this increase in productivity and growth enough to increase the tax revenue to an amount that will balance the fiscal system under the pressure of the rising health care expenditures or should the fiscal system change and seek more income by widening its base and finding a way to reduce its expenditure?

Though the relationship between HCE and health indicators such as life expectancy and mortality has been studied in the literature only a few spatial econometric studies exist and they are mostly focusing on comparing provinces within a country and the spillover effects between them. The question raised by Baltagi et al. (2018), whether health spending yields health benefits, has not yet been answered using spatial health econometrics. Also the analytic fiscal framework which has been developed by Connolly et al. (2017) has not been applied yet for the case of the OECD countries. Our variable of choice for the measurement of health, the Potential Years of Life Lost (PYLL) has not been studied as of now in its relation with HCE and since it is measured in years the results can be used in a OECD adjusted fiscal framework in order to calculate the fiscal impact it will have.

The intent of this study is to examine the total, direct and indirect effect of the Health care expenditures on the potential years of life lost for 29 OECD countries between the years 1990 and 2017 using spatial econometric models and use that information in order to calculate via an analytic framework the fiscal effect HCE will have for the government. This study does not intent to cover the effect HCE have on a global scale on PYLL since most of the countries do not provide data for this index. The framework on its own can be used with the necessary modifications for all cases and offers an alternative to the traditional methods used to evaluate the health expenses which are oblivious to the fiscal aspect of the matter. We find a negative relationship between HCE and PYLL which appears to have ta significant impact on the fiscal sustainability.

The rest of the study is organised as follows: In section 2 we provide a literature review on the subject. In the third section, we describe the data and the models used for our estimations as well as the methods involved. The fourth section entails the results of our study, the fifth is the discussion and in the last section we draw our conclusions.

Chapter 2

Literature review

2.1 Health care expenditures and Health

There are several studies that have examined the effect of HCE on health using variables like life expectancy on birth and mortality. Though the relationship is not crystal clear, most studies find that HCE improve indicators especially in lower-income countries. A study containing panel data from 175 countries grouped according to the geographic position and income level and covering years from 1995 to 2010 by Jaba et al. (2014) measured the relationship between health care expenditures and life expectancy using fixed effects models showed a significant relationship with the variation being wider in the less developed countries. Also, Liang and Tussing (2018) studied the effect the cyclicality of the government health expenditures has on the health of the population (measured in various indicators) in 135 developing countries from 1995 to 2014 using instrumental variables on a two stage least squares models and found a pro-cyclical pattern in low and middle income countries. Another study conducted by Arthur and Oaikhenan (2017) for the sub saharan countries showed an increased in life expectancy and a decrease in mortality due to a complementary action of private and public HCE. A panel data study performed by Rana et al. (2018) on 161 countries for the years 1995 to 2014 studying the relationship between healthcare expenditure and health outcomes (measured by infant mortality and life expectancy) for different levels on income showed significant variance across the different levels of income with the effect being stronger for the low-income countries. van den Heuvel and Olaroiu (2017) studied the same relationship for 31 European countries using life expectancy as a health measure but found social protection expenditures a more significant determinant than HCE. For the OECD countries, a study was performed by Linden and Ray (2017) who examined the relationship between life expectancy at birth and public and private health care expenditures. They analysed a panel of 34 OECD countries for the years 1970-2012. These countries were placed into three groups according to the size of their public HCE as a share of GDP. The study showed that in the highest public share cluster, life expectancy was affected similarly by privet and public HCE but this was not the case for the lower share clusters where this effect diminished and even turned negative for private HCE in the smallest share cluster.

2.2 Spatial econometric studies for HCE and Health

There are many studies about the spillover effects of the health care expenditures and health indicators but only a few that combine both the health and financial aspect and these examine it on a local level. A study by Pérez-Pérez et al. (2019) investigated the relationship between government expenditure on maternal health and maternal mortality (MM) estimating a spatial error model (SEM). Using administrative data from 2457 Mexican municipalities for the years 2000-2015, the research showed that MM and government expenditure on maternal health had no random distribution across the Mexican territories. Moreover, the highest levels of MM were found in the most socially vulnerable municipalities which exhibited the lowest levels of government expenditure on maternal health as well as limitations in manpower and in the amount of physical resources available for the promotion of maternal health. Another study performed by Rosenberger et al. (2005) estimated the relationship between health care expenditures for the treatment of circulatory problems, physical inactivity, obesity, and the supply of recreation opportunities in West Virginia using a spatial econometric model and maximum likelihood estimators. This research showed that the rates of physical inactivity which in turn are related to obesity and therefore health in general, relate positively to expenditures on health care treatments of diseases and disorders of the circulatory system. Finally a study carried by Castro et al. (2016) estimated the direct as well as the spillover effect of a federal grant on local health indicators in Brazilian municipalities using a Regression Discontinuity Design (RDD). The estimates show that the federal grant's spillovers improve local health indicators such as infant mortality rate, morbidity rate, hospitalisation and other health services both in major cities and small towns. The direct effects were reduced when they controlled for neighbours' federal grants, which showed the importance of the spillover effects and spatial interactions in explaining the federal grant's effect on health outcomes.

2.3 Fiscal Analytic Framework

There has not been much research done connecting health care spending and fiscal sustainability. The main framework for the examination of the fiscal consequences of Health Care Expenditures was developed by Connolly et al. (2017) and combines elements from human capital economics, public economics, and generational accounting in order to assess the intergenerational relationship between lifetime tax burden and social transfers. This framework gave the opportunity to examine inter-temporal and cross-sectoral consequences which are usually ignored by the traditional welfare economic approaches for evaluating health programs such as cost-effectiveness analysis used by public decision makers. It also allows us to study the impact of heath interventions on disability costs, loss taxes and reduced productive output that is attributed to poor health. This analytic approach can be applied to any public health intervention or policy change. For example, this framework was later used to study the difference in the tax transfers related to lifetime productive capacity, and the demand for government transfers related to education and healthcare, caused by the rotavirus morbidity and mortality between immunised and non-immunised cohorts up to the age of 65, in Ghana and Vietnam. The estimated net revenue attributed to the immunised cohort was $55.17 billion which was approximately a $29 million increase from the non-immunised cohort proving the usefulness of the model for governments in comparison to the traditional cost effectiveness analysis (Kotsopoulos et al., 2013). The framework was also used to study the fiscal impact of smoking cessation in Thailand (Connolly et al., 2018). In particular, the effect of investments in a pharmacological smoking cessation intervention on the country's future public economic budgets was investigated. This was accomplished by estimating the fiscal changes between the group who quitted smoking and the group who still continued to smoke. This changes included the health care costs, the increased wage due to increased productivity after the smoking cessation which in result translates into more tax revenue and the tax losses associated with the reduced consumption of tobacco. The analysis showed that, the earlier these interventions take place the more they will result in an increased tax revenue when compared to the tax revenues from people who continue the tobacco consumption, other of course than health benefits involved. This analytic framework is later described in the method section.

Chapter 3

Data & Methods

In this section we provide the information on how the data were collected and analysed in order to examine the relationship between HCE and PYLL. Also we provide the same information about the fiscal analytic framework that we will use to calculate the fiscal impact of health spending on the OECD countries.

3.1 Data

3.1.1 Data for the Econometric models

For the econometric models we use annual data as follows. For the measurement of the Health Care Expenditures in line with all other OECD studies, we use as our independent variable the per capita health spending retrieved from the OECD's health database. We study the years from 1990 to 2017 (T= 28) due to missing values in previous years for many countries used in the model. The existing missing values where filled by linear interpolation. This variable measures the final consumption of health care goods and services including personal health care (curative care, rehabilitative care, long-term care, ancillary services and medical goods) and collective services (prevention and public health services as well as health administration) but excluding spending on investments.

As a measure for health we used the Potential Years of Life Lost (PYLL) retrieved from the OECD database. We use the same techniques as we did for the HCE variable regarding the missing values. The reason we chose this variable instead of a different health indicator, such as life expectancy at birth or mortality rates is the fact that this indicator is highly correlated to Life Expectancy at birth (-0.833) in our data and it also summarises premature mortality by weighting deaths occurring at younger ages which might be preventable. So in a way it combines elements from the two main indicators commonly used. Another reason we decided to use PYLL as our dependent variable is the fact that it is measured in years per 100000 persons, something that will be proven very useful in the final part of this study, the fiscal analytic framework. PYLL are calculated by adding up the deaths that occur at each age and multiplying this with the number of remaining years to live up to a selected age limit. The age limit that is used in the calculation of this index which is 70 according to the OECD Health Statistics which is very close to the retirement age. Finally, the PYLL are standardised for cross-country and trend comparison, for each country and each year with the total OECD population in 2010 as the reference population for age standardisation.

As for control variables for the non-spatial model we used four more variables. Gini index was used as a proxy for the income inequality and was taken by the World Bank database. The percentage of the population with tertiary education from the age of 25 until the age of 64 was used as a proxy for eduction level since most of our countries in the sample are fairly developed and was retrieved from the OECD database. The Green House Gas emissions measured by tonnes per capita were used as a proxy for the air pollution and were retrieved also from the OECD database. Finally, the percentage of the population with access to improved water source from the Aquastat database. All the data are described on Table 3.1.

3.1.2 Data for the Fiscal Analytic Framework

For the fiscal framework we used the latest data available from the OECD database. The tax revenue indicator, measured in billion USD, was selected for the tax income and was divided by the total population in order to get a per capita amount. This indicator represents the revenue collected from taxes on income and profits, social security contributions, taxes levied on goods and services, payroll taxes, taxes on the ownership and transfer of property and other taxes (OECD, 2018b). As for the government costs, we used a fragment of the general government spending average, which for 2017 was 18.9 thousand USD per capita (OECD, 2019d).

Table 3.1: Descriptive statistics and sources of data

Variables	Obs.	Mean	Std.dev	Min	Max	Source
HCE *(per capita)*	812	2576.8	1677.7	130.7	10209.4	(OECD, 2018a)
PYLL *(per 100,000 inhabitants)*	812	4470.3	2090.1	1863.2	23994.4	(OECD, 2016)
Gini Index	812	36.529	5.0913	21.2	46.2176	WorldBank (2018)
Education *(% of population with tertiary)*	812	27.241	11.665	1.753	73.7507	(OECD, 2019a)
Green House Gas emissions *(tonnes per capita)*	812	12.682	5.5594	5.012	34.73	(OECD, 2019b)
Water access *(% of population)*	812	99.132	2.1641	83.6	100	(Aquastat, 2019)

HCE: Health Care Expenditures
PYLL: Potential Years of Life Lost

This fragment represented the average health, education and social protection spending which accounted for the 46,9% of the central government spending in 2017 for the OECD (OECD, 2019c). The methodology with which this data was treated is described in the next section.

The optimal choice of the discount rate for a government project in sectors where market failures exist and market prices do not exist or are misleading due to government intervention cannot be the market rate Park (2012). Therefore, the use of a discount rate based on guidelines might be more appropriate. A literature review done by Smith and Gravelle (2000) on the discounting economic evaluation of Health Care Interventions found that the most frequently specified rates are 3% and 5%. This is also the case in the guidelines of 9 OECD countries as shown in the review of the Cancer Research Economics Support Team (CREST) (Parkinson and Lourenço, 2015). We decided to use 3.5% as recommended by the National Institute for health and Care Excellence (NICE) guidelines (for Health and Excellence, 2013).

3.2 Methods

In this subsection we analyse the methods used for the econometric models as well as for the fiscal framework.

3.2.1 Econometric models

Health is a variable well known to have geographical concentration as it is well described in the health economics literature. Regarding health care spending, as was described in the previous chapter, the existence of unobservable risk factors of HCE have been described by Revelli (2006), Moscone and Knapp (2005), Moscone et al. (2007). Regarding health outcomes, conditions and pathologies, a number of studies has been performed such as the ones by Lorant et al. (2001) on mortality, Thouez et al. (1997) on cancer mortality, Alexander (1993) on child leukaemia, Gatrell and Whitelegg (1993) on childhood cancer, Hsiao et al. (2000) on asthma. As mentioned before some concentrations appear in a very localised form. On the other hand, other factors such as the environment, diet and lifestyle of the populations might have raised the prevalence of certain pathologies which will subsequently create considerable geographical concentrations of these pathologies also at the national level (Haining and Haining, 2003).

We chose spatial econometric models in order to study the short and long run spillover effects of health due to health care expenditure given the spatial dependence of our data which is also confirmed by the strongly statistically significant spatial rho in the spatial models we estimated. In spatial econometric models, the effect of an predictor variable that changes for a specific country will affect not only that country but also its neighbours. Those are the indirect effects, the off-diagonal elements of the matrix of total effects and indicate how a change in the predictor variable in country i affects the dependent variable in country j through a feedback process (Atella et al., 2014). The spatial autoregressive model (SAR) is given by equation 3.2 and the spatial Durbin model (SDM) by equation 3.3. We also estimate a non spatial fixed-effects model given by the equation 3.1 with more predictor variables than the spatial models in order to compare the results. This method was done in other studies with explanatory variables including, income and inequality indexes, environmental pollution, lifestyle indexes, education and others (van den Heuvel and Olaroiu, 2017), (Liang and Tussing, 2018). Our linear heterogeneous panel regression models are listed below.

The equation for the fixed effects model is:

$$y_{it} = \beta_0 + \beta_1 x_{1,it} + \beta_2 x_{2,it} + \beta_3 x_{3,it} + \beta_4 x_{4,it} + \beta_5 x_{5,it} + \alpha_i + u_{it} \tag{3.1}$$

where α_i is the unknown intercept for each country, y_{it} is the dependent variable PYLL , $x_{k,it}$ represents the independent variables (i.e.HCE and other variables used for control such as the gini index, education, air pollution measured by green house gas emissions and access to water). Also β_k is the coefficient for the independent variable k and u_{it} is the error term. Moreover *i* represents the country, t the time.

For the spatial models:

$$y_{it} = \alpha + \tau y_{it-1} + \rho \sum_{j=1}^{n} w_{ij} y_t + \sum_{k=1}^{K} x_{itk} \beta_k + \mu_i + \nu_{it} \tag{3.2}$$

$$y_{it} = \alpha + \tau y_{it-1} + \rho \sum_{j=1}^{n} w_{ij} y_t + \sum_{k=1}^{K} x_{itk} \beta_k + \sum_{k=1}^{K} \sum_{j=1}^{N} w_{ij} x_{jtk} \theta_k + \mu_i + \nu_{it} \tag{3.3}$$

where y_{it} our is health variable measured by PYLL in the ith country at time t, x_{it} is the HCE, μ_i is the country-specific effect and ν_{it} is the error term. The coefficient ρ measures how health in one country is related to the health in neighbouring countries on the condition of the explanatory variables. w is the contiguity matrix. We use a binary matrix which is the most commonly used in spatial health econometric studies according to Baltagi et al. (2018). This is a row-standardised, non-negative spatial weights matrix whose specification is based on the distance between the cross section observations, the OECD countries in our case. The contiguity matrix follows the "no island" rule and takes the following form:

$$\begin{cases} w_{ij} = 0, if\ i = j \\ w_{ij} = 1, if\ i\ and\ j\ are\ contiguous \\ w_{ij} = 0, if\ i\ and\ j\ are\ not\ contiguous \end{cases}$$

where w_{ij} the ijth element of a symmetric row standardised matrix of the countries' contiguity.

The violation of strict exogeneity due to the inclusion of the lagged dependent variable in dynamic spatial models is a problem that can be circumvented with the use of a spatial version of the system Generalised Method of Moments (GMM) methodology as proposed by Arellano and Bover (1995). However, we chose to use a maximum likelihood estimation (MLE) instead for the following reasons. According to Elhorst (2005) and Lee and Yu (2010), when a dynamic spatial panel model is present, if the spatial autoregressive variable and the time-lagged dependent variable are the only endogenous variables, MLE is a proper estimation method. The omission of several explanatory variables on the other hand, could lead to biased estimations. In order to control for this bias we took advantage of the format of the data and we also included a time lagged variable. More specifically, panel data allows us to control for unobserved heterogeneity caused by omitted variables by incorporating individual-specific effects (Baltagi et al., 2018). Also by using the autoregressive approach by Wooldridge (2002), we use the first lag of the dependent variable as an predictor variable in order to control for time-varying omitted variables. This method was also done by Eleftheriou and Sambracos (2019) in order to study the spillover effect of tourism on GDP growth.

Bidirectional causality between HCE and PYLL is a fact which could bias our estimations due to more endogeneity problems caused by the HCE variable being in that case endogenous. Despite the fact that there is no evidence in the literature suggesting the latter we performed a Granger Causality test for heterogenous panel data using bootstrap replications which was developed by Dumitrescu and Hurlin (2012). The test showed that HCE does not granger cause PYLL (Table 3.3)

Table 3.2: Hausman test

$chi2(2)$	2.32(0.3136)

H_0: Difference in coefficients not systematic
P-value in parenthesis

While the Hausman test on the respective fixed and random effect variations

Table 3.3: Granger causality test

Z_{bar}	8.3435(0.2230)
$Z_{bar-tilde}$	6.8361(0.2230)

H_0: HCE does not Granger-cause PYLL
P-value in parenthesis

of the spatial models indicated the use of random effects, we chose to use fixed effects based on the following rationale. he random-effects model assumes that the country-specific random-effects are exogenous to the other included regressors (in our case the HCE). However, it seems more plausible that country specific characteristics shape the way the exogenous HCE common to most OECD countries impacts differentially on the individual country HCE. Having this in mind and also that some of the p-values in the Hausman test are not so low (Table 3.2), it might be preferable to focus on the fixed-effects specifications (Alexiadis et al., 2013).

3.2.2 Diagnostic tests

We performed a series of diagnostic tests to our data for the existence of unit roots and cross-sectional independence. First, we tested for the existence of cross-sectional dependence (CD). We calculated the Breusch-Pagan Lagrange Multiplier test statistic for cross-sectional independence in the residuals of the fixed effects regression model following Greene (2003), the Pesaran test for cross-sectional dependence (Pesaran, 2007) and the Moran's I test statistic according to Kelejian and Prucha (2001). The difference between Moran's I and the other CD statistics is that it exploits the spatial structure of the data and therefore treating with added gravity the contiguity of countries (Baltagi and Moscone, 2010). All the tests, shown in Table 3.4 demonstrate the existence of cross-sectional dependence .

Table 3.4: Cross-sectional dependence tests

Breusch-Pagan LM test	Pesaran test	Moran's I
4539.893(0.0000)	20.634(0.0000)	0.1088(0.0001)

H_0: No cross-sectional dependence
P-value in parenthesis

Since cross sectional dependence was present in our data, we test for stationarity using the Panel Unit Root Test in the Presence of Cross-section Dependence (CIPS) developed by Pesaran (2007) both with intercept and intercept with trend. This test has been designed to test the unit root hypothesis when the variable under study has a factor structure. However, according to Baltagi and Moscone (2010), this test is also robust when other sources of cross-section dependence are present such as the spatial autoregressive process, as has been shown by Monte Carlo simulations. The statistics for the CIPS tests are given in Table 3.5. As a robustness check, we also calculated the Im Pesaran Shin (IPS) test Im et al. (2003) and the panel unit roots test proposed by Breitung (2001), which do not account for cross-section dependence in the data. The Breitung statistic is a modification of the augmented Dickey Fuller statistic and has more power than IPS if individual specific trends are included (Baltagi, 2008). The statistics of these tests are given in Table 3.6. These tests concluded that PYLL and HCE are non-stationary variables but the CIPS tests on lagged values of PYLL show that some panels might be stationary.

Table 3.5: Unit root tests: CIPS

	Number of lags		
	1	2	3
PYLL	-2.053	-2.073*	-2.250**
HCE	-1.463	-1.915	-2.114*
with intercept			
PYLL	-2.601*	-2.453	-2.685**
HCE	-1.643	-1.975	-2.240
with intercept and trend			

H_0 :*Non-stationarity*
HCE: Health Care Expenditures
PYLL: Potential Years of Life Lost
****Significance at 1% level; **significance at 5% level; and *significance at 10% level.*

Table 3.6: Unit root tests

Variable	IPS *Z-t-tilde bar*	Breitung
	with intercept	
PYLL	-0.1947(0.4228)	13.9136(1.0000)
HCE	17.0137(1.0000)	19.5511(1.0000)
	with intercept and trend	
PYLL	-0.0866 (0.1932)	5.2029 (1.0000)
HCE	0.3354 (0.6313)	6.1635 (1.0000)

HCE: Health Care Expenditures
PYLL: Potential Years of Life Lost
H_0*: Panels contain unit roots*
P-value in parenthesis

3.2.3 Fiscal Analytic Framework

For the calculation of the fiscal impact we base our methodology on the analytic framework developed by Connolly et al. (2017) adjusted for the case of the OECD countries as shown in equation 3.4. For the time parameter, we use the long run HCE coefficient (0.67) from the equation 3.3 as the time(T) that will be used for the calculation of the Present Value. This coefficient represents the mean change in years if we increase the HCE per capita by $1. The Tax is the total tax revenue of the OECD countries ($15638.23 million) divided by the total OECD population (1257.114 million persons, retrieved from OECD (2015)), in order to get a per capita index ($12439.786). For the $Cost$, the average per capita government spending is $18258 but we are not interested in the total amount. Instead, we sum the average percentages health, education and social protection represent in the government spending of OECD countries which is 46,9%. That percentage in turn corresponds to $8563 per capita. So the annual per capita flow is $3876.786 or $323.065 per month. We hypothesise that the flow is the same for every time period. We use the 3,5% discount rate as mentioned in the data section. Since, the coefficient gives a time period smaller than a year we convert it to months (8). We also convert our annual discount rate to a monthly rate (0.2916%). This in result gives us a Present Value (PV) of $2551.04.

$$Discounted\ tax\ (PV)_{fiscal} = \sum_{t=0}^{T} \frac{Tax - Cost}{(1+r)^t} \tag{3.4}$$

where, Tax is the per capita revenue from direct and indirect taxes plus taxes on the payroll (national insurance) and $Cost$ the per capita government spending on health, education and social protection. Also, r is the discount rate and t the time.

Chapter 4

Results

In this section we provide the results regarding the relationship between the health care expenditure and health. Also we estimate the fiscal effect they will have using the analytic framework.

4.1 Estimates for the effect of Health care expenditures on Health

The non-spatial fixed-effects model (Eq 3.1) shows a statistically significant negative relationship between HCE and PYLL as it was expected (Table 4.1). On the other hand, the Gini index, Education and Green House Gas emissions does not appear to be statistically significant. This may have occurred due to the relative homogeneity OECD have in matters such as education, air pollution and inequality. The other statistically significant variable is the access to improved water source which has however the smallest variance amongst the countries. Experiments that were carried omitting some of the control variables showed no real difference in the results regarding their statistical significance.

In the spatial models both the total short-run and long-run effects as well as the coefficient of the HCE are negative. In the SDM model, which is our model of choice, for the direct effects, the results show a short-run coefficient of -.7818 while for the long-run direct effects a coefficient of -.04977. This shows that given all the other variables remain unchanged, an increase in HCE will have a bigger effect in the short-run for a given country. The indirect effects show an interesting

Table 4.1: Empirical results non-spatial model

Variable	Coefficient	Standard Deviation
HCE	-.3623404**	.1359163
Gini Index	23.23093	14.44385
Education	-12.37229	20.06619
Water access	-400.6279***	138.9434
GHG emissions	166.3163	116.7253

****Significance at 1% level; **significance at 5% level; and *significance at 10% level.*

result. The short-run effect appears to be positive which means that there will be an increase in PYLL as a spillover effect. The long-run spillover effects though appear negative with a coefficient of -.6205. The spatial effects are shown on Table 4.2, these results both on short and long run are strongly statistically significant. The negative effect of the HCE on PYLL is also confirmed by the non-spatial model as seen on Table 4.1.

Table 4.2: Empirical results spatial models

Variable	SAR model	SDM model
Lagged PYLL	40.999***(0.014251)	16.73576***(0.0141733)
Spatially lagged PYLL	-172.5657***(0.0274858)	86.86148***(0.0271023)
HCE	-83.946***(0.0148775)	-26.9368***(0.0171725)
Spatially lagged HCE		-20.74227***(0.0184998)
Short-run direct effects	-2.357535***(0.0004862)	-.7818747***(0.0003254)
Short-run indirect effects	1.873876***(0.0004665)	.2392126***(0.0003387)
Short-run total effects	-.4836597***(0.0000624)	-.5426621***(0.0001473)
Long-run direct effects	-.178755***(0.0005544)	-.0497706***(0.0004212)
Long-run indirect effects	-.4544884***(0.0005048)	-.6205798***(0.0003292)
Long-run total effects	-.6332433*** (0.0000946)	-.6703505***(0.0002033)

****Significance at 1% level; **significance at 5% level; and *significance at 10% level. Robust standard errors are reported in parentheses. The SDM model was selected over the SAR for its lower value on the Akaike and Bayes – Schwarz information criteria. The regression results were estimated in STATA using the -xsmle- command.*

4.2 Estimates for the fiscal analytic framework

Using the long run HCE coefficient from the equation 3.3 we get that a $1 increase in HCE per capita will result in a decrease of 0.67 years (8 months) lost per 100000 persons. Using the monthly flow and monthly rate (as described in the methods section) for the 8 months in our equation 3.4, we calculated a PV of $2551.04. This means a $2551.04 government revenue for a $1 increase in HCE per capita.

Chapter 5

Discussion

Trying to determine whether HCE reduce PYLL (and therefore improve health), our research gives an answer to a fundamental question raised by Baltagi et al. (2018), whether more spending on health care yields health benefits. For the OECD countries, both spatial and non-spatial models showed a negative relationship as expected. As for the spillover effects between countries, the results were mixed. These spillover effects could be attributed to many factors such as competition between health care providers of neighbouring countries, medical tourism opportunities, existence of technological clustering, prevalence of transmittable diseases and other environmental or social factors. That fact that the short-run indirect effects had a positive coefficient was an unexpected; however, this result does not negate the nature of the spillover effects since the long-run indirect effects remain negative. This unexpected effect might have been created due to the indirect effects of omitted variables such as environmental risks and lifestyle which show geographical concentrations and affect the healths status of neighbours resulting in a biased estimate of the spatial effects.

As for the fiscal sustainability, the fiscal analytic framework we calculated showed that an increase in HCE per capita by $1 will return in the long run $2551.04 as profit for the government. In that notion and given that PYLL is an index that focuses on preventable diseases, governments should focus their HCE on preventing diseases rather than treating them afterwards in order to improve their fiscal sustainability and minimise their costs in the Health Care sector.

Of course, more research should be done using PYLL as a health indicator outside the OECD. Unfortunately, the countries that provide data are limited but will increase in time. Since this research was carried on a specific group of countries, conclusions for other countries should be made with caution. Future research should focus on examining different groups of countries according to income level, welfare indexes and health system. Certain components of HCE should also be examined regarding their effect on PYLL in order to understand better where to spend more and where to spend less. In this way, the results will be more precise for governments and organisations to use. Policy makers should focus on their country-specific data in order to get the most appropriate estimations for their governments.

Chapter 6

Conclusions

In conclusion, the purpose of this study was to examine the relationship between Health Care Expenditure and Health as well as find their marginal impact on fiscal budgets. Using a panel of 29 OECD countries followed over 28 years we found a positive relationship between Health Care Expenditure and health which translated financially in to $2551.04 profit for the government per $1 increase in Health Care Expenditure per capita. This study contributes to the literature by using the Potential Years of Life Lost as a health indicator as well as spatial econometrics in order to study the relationship and the spillover effects between health care expenditure and health in the OECD countries. The use of Potential Years of Life Lost index into a Present Value fiscal analytic framework creates new ways of evaluating of Health Care Expenditures and provides a new tool for the calculation of the fiscal impact they have.

Bibliography

Alexander, F. E. (1993). Viruses, clusters and clustering of childhood leukaemia: a new perspective? *European Journal of Cancer*, 29(10):1424 – 1443.

Alexiadis, S., Eleftheriou, K., and Nijkamp, P. (2013). Regional inequalities and the impact of 'matching technology'on the arrival rate of employment offers: A theoretical and empirical analysis. *Papers in Regional Science*, 92(2):285–304.

Aquastat (2019). Access to improved water source. Available from: http://www.fao.org/nr/water/aquastat/data/query/index.html.

Arellano, M. and Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of econometrics*, 68(1):29–51.

Arthur, E. and Oaikhenan, H. E. (2017). The effects of health expenditure on health outcomes in sub-saharan africa (ssa). *African Development Review*, 29(3):524–536.

Atella, V., Belotti, F., Depalo, D., and Mortari, A. P. (2014). Measuring spatial effects in the presence of institutional constraints: The case of italian local health authority expenditure. *Regional Science and Urban Economics*, 49:232 – 241.

Baltagi, B. (2008). *Econometric analysis of panel data*. John Wiley & Sons.

Baltagi, B. H., Lagravinese, R., Moscone, F., and Tosetti, E. (2017). Health care expenditure and income: a global perspective. *Health economics*, 26(7):863–874.

Baltagi, B. H. and Moscone, F. (2010). Health care expenditure and income in the oecd reconsidered: Evidence from panel data. *Economic Modelling*, 27(4):804–811.

Baltagi, B. H., Moscone, F., and Santos, R. (2018). *Spatial Health Econometrics*, chapter 13, pages 305–326. Emerald Publishing Limited.

Breitung, J. (2001). The local power of some unit root tests for panel data. In *Nonstationary panels, panel cointegration, and dynamic panels*, pages 161–177. Emerald Group Publishing Limited.

Burtless, G. (2006). Cross-National Evidence on the Burden of Age-Related Public Transfers and Health Benefits. Working Papers, Center for Retirement Research at Boston College wp2006-6, Center for Retirement Research.

Castro, M., Mattos, E., and Patriota, F. (2016). Spillovers in a decentralized health economy.

Connolly, M. P., Kotsopoulos, N., Postma, M. J., and Bhatt, A. (2017). The fiscal consequences attributed to changes in morbidity and mortality linked to investments in health care: A government perspective analytic framework. *Value in Health*, 20(2):273 – 277.

Connolly, M. P., Kotsopoulos, N., Suthipinijtham, P., and Rungruanghiranya, S. (2018). Fiscal impact of smoking cessation in thailand: A government perspective cost-benefit analysis. *Asia Pacific Journal of Public Health*, 30(4):342–350.

Dormont, B., Grignon, M., and Huber, H. (2006). Health expenditure growth: reassessing the threat of ageing. *Health economics*, 15(9):947–963.

Dumitrescu, E.-I. and Hurlin, C. (2012). Testing for granger non-causality in heterogeneous panels. *Economic Modelling*, 29(4):1450 – 1460.

Eleftheriou, K. and Sambracos, E. (2019). Tourism growth nexus and spatial spillovers: Evidence from greece. *Tourism Economics*, 25(2):297–302.

Elhorst, J. P. (2005). Unconditional maximum likelihood estimation of linear and log-linear dynamic models for spatial panels. *Geographical analysis*, 37(1):85–106.

for Health, N. I. and Excellence, C. (2013). Guide to the methods of technology appraisal.

Gatrell, A. C. and Whitelegg, J. (1993). Incidence of childhood cancer in preston and south ribble.

Gong, L., Li, H., and Wang, D. (2012). Health investment, physical capital accumulation, and economic growth. *China Economic Review*, 23(4):1104 – 1119.

Greene, W. H. (2003). *Econometric analysis*. Pearson Education India.

Haining, R. P. and Haining, R. (2003). *Spatial data analysis: theory and practice*. Cambridge University Press.

Hartwig, J. (2010). Is health capital formation good for long-term economic growth? âââ panel granger-causality evidence for oecd countries. *Journal of Macroeconomics*, 32(1):314 – 325.

Heshmati, A. (2001). On the Causality between GDP and Health Care Expenditure in Augmented Solow Growth Model. SSE/EFI Working Paper Series in Economics and Finance 423, Stockholm School of Economics.

Hitiris, T. and Posnett, J. (1992). The determinants and effects of health expenditure in developed countries. *Journal of Health Economics*, 11(2):173 – 181.

Howdon, D. and Rice, N. (2018). Health care expenditures, age, proximity to death and morbidity: Implications for an ageing population. *Journal of Health Economics*, 57:60 – 74.

Hsiao, C. K., Tzeng, J.-Y., and Wang, C.-H. (2000). Comparing the performance of two indices for spatial model selection: application to two mortality data. *Statistics in Medicine*, 19(14):1915–1930.

Im, K. S., Pesaran, M. H., and Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of econometrics*, 115(1):53–74.

Jaba, E., Balan, C. B., and Robu, I.-B. (2014). The relationship between life expectancy at birth and health expenditures estimated by a cross-country and time-series analysis. *Procedia Economics and Finance*, 15:108 – 114. Emerging Markets Queries in Finance and Business (EMQ 2013).

José J. Martín Martín, M. P. L. d. A. G. . M. D. C. G. (2011). Review of the literature on the determinants of healthcare expenditure. *Applied Economics*, 43(1):19–46.

Kelejian, H. H. and Prucha, I. R. (2001). On the asymptotic distribution of the moran i test statistic with applications. *Journal of Econometrics*, 104(2):219–257.

Kotsopoulos, N., Connolly, M. P., Postma, M. J., and Hutubessy, R. C. (2013). Fiscal consequences of changes in morbidity and mortality attributed to rotavirus immunisation. *Vaccine*, 31(46):5430 – 5434.

Layte, R. (2007). An analysis of the impact oof age and proximity of death on health care costs in ireland. Technical report, ESRI Working Paper.

Lee, L.-f. and Yu, J. (2010). A spatial dynamic panel data model with both time and individual fixed effects. *Econometric Theory*, 26(2):564–597.

Liang, L.-L. and Tussing, A. D. (2018). The cyclicality of government health expenditure and its effects on population health. *Health Policy*.

Linden, M. and Ray, D. (2017). Life expectancy effects of public and private health expenditures in oecd countries 1970âăă2012: Panel time series approach. *Economic Analysis and Policy*, 56:101 – 113.

Liu, B. and Yang, Z. (2018). Population aging shock and fiscal sustainability in china: Mechanism analysis and effect simulation. *The Singapore Economic Review*, 0(0):1–22.

Lorant, V., Thomas, I., Deliège, D., and Tonglet, R. (2001). Deprivation and mortality: the implications of spatial autocorrelation for health resources allocation. *Social Science & Medicine*, 53(12):1711 – 1719.

Moscone, F. and Knapp, M. (2005). Exploring the spatial pattern of mental health expenditure. *Journal of mental health policy and economics*, 8(4):205.

Moscone, F., Knapp, M., and Tosetti, E. (2007). Mental health expenditure in england: a spatial panel approach. *Journal of Health Economics*, 26(4):842–864.

Mushkin, S. J. (1962). Health as an investment. *Journal of Political Economy*, 70.

Nozaki, M., Kashiwase, K., and Saito, I. (2017). Health spending in japan: Macro-fiscal implications and reform options. *The Journal of the Economics of Ageing*, 9:156 – 171.

OECD (2015). Population data. Available from: https://www.oecd-ilibrary.org/content/data/ccca3172-en.

OECD (2016). Health status. Available from: https://www.oecd-ilibrary.org/content/data/data-00540-en.

OECD (2017a). *Health at a Glance 2017*. Available from: https://www.oecd-ilibrary.org/content/publication/health_glance-2017-en.

OECD (2017b). *Pensions at a Glance 2017*. Available from: https://www.oecd-ilibrary.org/content/publication/pension_glance-2017-en.

OECD (2018a). Health expenditure indicators. Available from: https://www.oecd-ilibrary.org/content/data/data-00349-en.

OECD (2018b). Tax revenue. Available from: https://www.oecd-ilibrary.org/content/data/d98b8cf5-en.

OECD (2019a). Adult education level(indicator). Available from: https://data.oecd.org/eduatt/adult-education-level.htm.

OECD (2019b). Air and ghg emissions (indicator). Available from: https://data.oecd.org/air/air-and-ghg-emissions.htm.

OECD (2019c). Central government spending. Available from: https://www.oecd-ilibrary.org/content/data/83a23f1b-en.

OECD (2019d). General government spending. Available from: https://www.oecd-ilibrary.org/content/data/d853db3b-en.

Park, S. (2012). Optimal discount rates for government projects. *ISRN Economics*.

Parkinson, B. and Lourenço, R. D. A. (2015). Discounting in economic evaluations in health care: A brief review.

Pérez-Pérez, E., Serván-Mori, E., Nigenda, G., Ávila-Burgos, L., and Mayer-Foulkes, D. (2019). Government expenditure on health and maternal mortality in méxico: A spatialâeconometric analysis. *The International Journal of Health Planning and Management.*

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of applied econometrics*, 22(2):265–312.

Rana, R. H., Alam, K., and Gow, J. (2018). Health expenditure, child and maternal mortality nexus: a comparative global analysis. *BMC international health and human rights*, 18(1):29.

Revelli, F. (2006). Performance rating and yardstick competition in social service provision. *Journal of Public Economics*, 90(3):459 – 475. Special issue published in cooperation with the National Bureau of Economic Research: Proceedings of the Trans-Atlantic Public Economics Seminar on Fiscal Federalism 20âÂÂ22 May 2004.

Rivera, Berta Currais, L. (1999). Economic growth and health: direct impact or reverse causation? *Applied Economics Letters*, 6(11):761–764.

Rosenberger, R. S., Sneh, Y., Phipps, T. T., and Gurvitch, R. (2005). A spatial analysis of linkages between health care expenditures, physical inactivity, obesity and recreation supply. *Journal of Leisure Research*, 37(2):216–235.

Schultz, T. W. (1961). Investment in human capital. *The American Economic Review*, 51(1):1–17.

Smith, D. and Gravelle, H. (2000). *The practice of discounting economic evaluation of health care interventions.* University of York, Centre for Health Economics.

Thouez, J., Emard, J., Beaupre, M., Latreille, J., and Ghadirian, P. (1997). Space-time analysis of the incidence of cancer in certain sites of quebec: 1984-1986 and 1989-1991. *Canadian Journal of Public Health*, 88(1):48–51.

van den Heuvel, W. J. A. and Olaroiu, M. (2017). How important are health care expenditures for life expectancy? a comparative, european analysis. *Journal of the American Medical Directors Association*, 18(3):276.e9–276.e12.

Weil, D. N. (2006). Population aging. Working Paper 12147, National Bureau of Economic Research.

Well, D. N. (2007). Accounting for the effect of health on economic growth. *The Quarterly Journal of Economics*, 122(3):1265–1306.

Wooldridge, J. M. (2002). Introductory econometrics, a modern approach, 2003. *New York: South-Western College Publishing*.

WorldBank (2018). Gini index. Available from: https://data.worldbank.org/indicator/SI.POV.GINI.