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The Interrelations between Health, Human Capital and Economic Growth.

Empirical Evidence from the OECD Countries and Portugal

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To

António and Maria

Abstract

The main scope of this study is to analyze the role of health on economic growth assuming that health status is a component of human capital, therefore interacting with both, human capital qualifications and economic performance. Health as an integrated part of human capital has assumed an increasing importance in the growth literature over the past decades, being now widely recognized that health, like education, is also an essential factor of labour productivity and, consequently, of economic growth. Despite important achievements made on health status allowing people to live better and for a longer period of time, there are still several issues to analyze in what concerns the economic performance of the developed countries. In fact, these countries face important challenges related to the ageing of the population, the increasing incidence of chronic diseases and an increasing financial pressure on their health and social security systems.

In this context, the main objective of this dissertation is to provide empirical evidence that shows the impact of health status on economic growth and highlight the complex interrelations between health, education and income through a cumulative causation mechanism able to generate a virtuous circle of economic growth with expanding tendencies. In order to capture the feedback effects between health, education and income, appropriate econometric specifications and estimation techniques are used based initially on panel data analysis. In a latter phase, a simultaneous equation model is built in order to capture the cumulative causation tendencies between the core variables of the model. The models are applied to the OECD countries and to Portugal.

Our empirical findings show that health is indeed an important factor in explaining growth and convergence in the OECD countries and the Portuguese regions at a district level. Economic factors and education are also important in explaining health status. It is also shown that the cumulative causation mechanism is a useful tool to explain the interactions between health, education and economic growth in Portugal. To a deeper understanding of the growth process, health factors and human capital qualifications must be included in the empirical analysis.

In general, our dissertation corroborates with the thesis that health improvements have significant benefits on economic growth and therefore it should be considered as an important component of human capital along with education. Investing in individuals' education and health is important not only for an increasing wellbeing but also for a sustainable economic

growth. Empirical evidence of this positive impact as well as on the linkages between health, education and economic growth are important guidelines for policy decision makers.

Resumo

Este estudo tem por principal objetivo analisar o papel da saúde no crescimento económico, assumindo que o estado de saúde é um componente do capital humano e, portanto, que interage simultaneamente com os níveis de qualificação e com a performance económica. Nas últimas décadas, a saúde como parte integrante do capital humano tem assumido uma importância crescente na literatura sobre crescimento económico, sendo hoje amplamente reconhecido que a saúde, como a educação, é também um fator essencial da produtividade do trabalho e, consequentemente, do crescimento económico. Apesar dos importantes resultados já alcançados no estado de saúde dos países mais desenvolvidos, que permitem que as pessoas vivam mais e melhor, alguns aspetos que caraterizam as economias destes países justificam a sua análise. De facto, estes países deparam-se com importantes desafios relacionados com o envelhecimento da população, a crescente incidência de doenças crónicas e a crescente pressão financeira sobre os respectivos sistemas de segurança social e de saúde.

Neste contexto, o principal objetivo desta dissertação é evidenciar empiricamente o impacto do estado de saúde no crescimento económico e destacar as interligações complexas entre saúde, educação e rendimento, através de um mecanismo de causalidade cumulativa capaz de gerar um ciclo virtuoso de crescimento económico com tendências expansionistas. No sentido de captar os efeitos de *feedback* entre saúde, educação e rendimento, são utilizadas especificações econométricas adequadas e, numa primeira fase, técnicas de estimação baseadas em análises de dados em painel. Numa fase posterior, é desenvolvido um modelo de equações simultâneas de modo a captar as tendências de causalidade cumulativas entre as variáveis centrais do modelo. Os modelos são aplicados aos países da OCDE e a Portugal.

Os nossos resultados empíricos mostram que a saúde é de facto um fator importante para explicar os processos de crescimento e convergência dos países da OCDE e das regiões Portuguesas ao nível dos distritos. Os fatores económicos e a educação são também importantes para explicar o estado de saúde. É também demonstrado que o mecanismo de causalidade cumulativa é útil para explicar as interligações entre saúde, educação e crescimento económico em Portugal. Para um entendimento mais profundo do processo de crescimento, os fatores de saúde e a qualificação do capital humano devem ser considerados na análise empírica.

Em termos gerais, a nossa dissertação corrobora a tese de que um melhor estado de saúde tem benefícios significativos para o crescimento económico e, deste modo, deve ser considerado um importante componente do capital humano, a par da educação. O investimento na educação e saúde dos indivíduos é importante não só para um maior bem estar mas também para um crescimento económico sustentável. Evidência empírica deste impacto positivo bem como das ligações entre saúde, educação e crescimento económico constituem importantes linhas de orientação para os decisores políticos.

Contents

List of Figures

List of Tables

Chapter 1

Introduction

In this dissertation we attempt to analyze the relevance of health status on economic growth explaining the mechanism through which health interacts with human capital and economic performance generating a cumulative causation process that boosts growth. Empirical evidence is given to support these ideas with respect to the OECD countries and Portugal.

It is widely recognized that improvements on health over the last century in most developed countries are a consequence but also a condition for a better economic performance. These health achievements are well illustrated by the gain of about 30 years in life expectancy of the most developed countries which is considered one of the most important attainments of the 20th century (Christensen *et al*., 2009). However, it is also consensual that additional gains will be harder to obtain, since OECD countries have already reached a high average level of life expectancy and now they must deal with the challenges of sustaining an ageing population and the burden of an increasing prevalence of chronic diseases.

These two trends – the ageing of the population and the incidence of chronic diseases (that are responsible for high levels of mortality and morbidity) – are important issues of concern that need to be analyzed in the light of economic efficiency and the way they affect economic performance. Our main scope is to contribute to a deeper understanding of these trends that characterize the OECD health systems and to provide empirical evidence that measure their impact on economic performance.

While the impact of health status is widely accepted as a key factor for the worker's productivity and largely studied (at a microeconomic level), the idea that human capital in the growth perspective should include, beyond worker's education/skills, also health factors is relatively recent. Moreover, most of the macroeconomic studies that analyze the impact of health on economic growth focus essentially on less developed countries or on comparisons between less developed and rich countries. Nevertheless, in recent years this analysis has also been extended exclusively to rich countries with health-related issues on the centre of the economic and political debate in most developed countries. In fact, in what respects the European Union (UE), the recognition of the importance of health factors on labour markets is well illustrated with the adoption of the strategy – "Together for Health: A Strategic Approach for the EU 2008-2013[1]" – by

[1] Commission of the European Communities (2007).

the EU governments and the European Commission in 2007 and it is crucial to the implementation of the “Lisbon Strategy”[2].

Another important aspect to notice is that, while for less developed countries empirical results are unanimous in finding a positive impact of health on economic growth, in what concerns studies focusing exclusively on rich countries the existing empirical evidence is mixed, depending on the health indicators used or the countries considered in the analysis. The great complexity that characterizes the interrelations between education, health and economic growth may explain, at least partly, these mixed results. Other reasons are related with restrictions concerning data availability, difficulties in measuring health or the use of the most adequate methodologies to take into account some specific econometric issues like the endogeneity of the regressors or the mutual causality effects between variables. At the same time we consider that these mixed results justify the need for further research.

Having these difficulties in mind, our aim is to contribute to this debate providing evidence of the impact of health factors on economic performance of rich countries applying different econometric methodologies that are more adequate to deal with the reversal causality between health, education and economic growth. The interaction between these three dimensions is explained by an economic mechanism based on cumulative causation characteristics with increasing returns to scale properties steaming mostly from a broader notion of human capital that includes health status. As many authors have already explored (Rivera and Currais, 2003; Fielding and Torres, 2005, among others) there are reversal effects between education, health and standards of living that can act simultaneously to stimulate and enhance growth. Human capital (education and health) improvements enhance economic growth but economic growth also contributes to higher levels of human capital through improvements in education and health conditions.

We structure this dissertation in six main parts. Besides the introduction, the second chapter reviews the concept of human capital and its importance on economic growth. We also analyze two different methodological approaches that illustrate the two main streams in economic growth theory, the neoclassical and the endogenous growth

[2] The Lisbon Strategy was adopted in the year 2000 and aimed to "make Europe, by 2010, the most competitive and the most dynamic knowledge-based economy in the world". It was followed by Europe 2020 strategy that aims a “smart, sustainable and inclusive growth” (European Council, 2010).

perspectives. In Chapters 3 and 4 our study focus on the OECD countries while chapters 5 and 6 consider exclusively the Portuguese economy, which is one of the OECD countries that has registered the most important health improvements in the last decades.

In particular, Chapter 3 studies the impact of human capital (including both education and health) on economic growth using as a case study a sample of the OECD countries. To do so we estimate growth equations of the Solow type using panel data estimation techniques to overcome the endogeneity problems. The sample is constituted by 22 OECD countries and the time spans from 1980 to 2004 where data is available. With this study we intend to evidence that health conditions should be proxied by health factors different from the usual ones, such as life expectancy or infant mortality.

In Chapter 4 we analyze the determinants of life expectancy (at different ages) as a proxy for the health status of the OECD countries' population for the period 1980-2004. Despite the large increase in life expectancy in most developed countries in the last decades, there are still persistent differences between genders, well reflected in life expectancy at 65 years old (higher for women than for men). Since socio-economic factors, health resources and lifestyles can be seen as the main determinants of health status, we analyze whether these factors play a different role in explaining life expectancy according to age and gender. However, in this kind of analysis a very common methodological problem is the reversal causality between education and income level in determining health status. Therefore, to take into account this problem, we use a production function of health to explain life expectancy (at birth for total population and according to gender and at 65 years old according to gender) and an IV/GMM estimation approach that accounts for possible endogenous regressors. Our evidence shows that income, education and health resources (through consultations) are important factors affecting positively life expectancy and that risky lifestyles (tobacco and alcohol consumption) are harmful to health. Some interesting findings may help to understand differences between males and females, since the major determinants affecting men's and women's health status are different.

In Chapters 5 and 6 we analyze the role of health factors in the Portuguese economy in two different perspectives. Two main factors justify the pertinence of using the Portuguese economy as a case study. First, there are severe geographical asymmetries between *littoral* and *interior* regions that are also reflected in strong inequalities in the access to health care services and that may affect the economic performance of these regions. Moreover, as far as we know there is no empirical evidence of the role of health on regional growth for the Portuguese economy. On the other hand, Portugal is one of the OECD countries that suffered major changes in its demographic structure – due to both a huge increase of life expectancy and decrease of fertility rates – being today characterized by an ageing society. Having these characteristics in mind, in Chapter 5 we intend to highlight the contribution of health on regional economic growth and convergence across the Portuguese regions at the district level for the period 1996-2006. Once more, we consider human capital in a broader perspective encompassing not only educational qualifications but also health conditions. Since empirical evidence at a regional level is not robust in the literature supporting this issue, in this chapter we try to fill this gap and bring additional evidence of the relevance of health on regional growth considering the Portuguese districts. We employ a panel data approach for the period 1996-2006 taking into account specific regional differences. We also analyze whether there are differences between the *littoral* (coastal) and the *interior* (in-land) districts in what concerns health conditions and how they affect their convergence process.

In Chapter 6 we implement a simultaneous equation system with the aim to explain the feedback effects between health, human capital and economic growth through a cumulative causation mechanism with increasing returns properties. The first relation analyzes the determinants of infant mortality in Portugal, representing the most significant reduction among the OECD countries since the seventies. While this very positive performance is a direct consequence of the investments made in the health sector, it is also important to note that it is a result of other socioeconomic factors outside the health system (mainly in the education system) that have contributed significantly to an improvement of the living conditions. Therefore, in order to understand the decline of infant mortality in Portugal we must consider simultaneously the improvements that have been made on education and economic performance. In particular we consider a three equation system to determine simultaneously the interactions between infant mortality rate, education and per capita income growth during the period 1972-2009. Our empirical evidence shows that the proposed model is adequate to highlight the potential links between these core factors.

Finally, in Chapter 7 we summarize the main findings and purpose some policy implication issues.

Chapter 2

Human Capital, Health and Economic Growth: A Review

2.1 Introduction

Gross domestic product (GDP) per capita is traditionally used as an indicator of the standards of living of a nation's population. Hence, a primary goal for governments and economic policy makers should be to raise the level of national output, assuring higher standards of wellbeing. Having this in mind, economists have tried from long time to explain what the main sources of economic growth are as well as to find the more suitable approaches to describe the growth process. While for the former it is largely accepted the role of capital investment and human capital as the main driving forces of economic growth, in what concerns the question of how to model and describe the economic growth process, there isn't a straight answer (López-Casasnovas *et al*., 2005). For simplicity, we can divide growth theories in two main streams, the exogenous and the endogenous growth theories.

In the last decades the human capital concept, traditionally associated to education, has been developed to include also health factors. In fact, health plays a relevant role in explaining the worker's productivity and, at the national level, the economy's performance. Therefore, it was necessary to adapt the theory of economic growth in a way to capture the effects of health factors as determinants of economic growth and convergence.

Assuming a broader notion of human capital that encompasses health along with education implies, however, additional difficulties namely with what concerns the empirical analysis. These difficulties are related with restrictions on the availability of adequate data, which limits international comparisons, but also with the multiple and complex pathways through which health can affect growth and that are directly associated with the reverse causality effects between health, education and growth.

In this chapter our aim is to show how health capital has been integrated in the theory of economic growth. With this purpose in the next section we explain the role of human capital as a production factor. Section 2.3 introduces health as a production factor in the growth process and section 2.4 explains the main mechanisms through which health affects economic growth. In section 2.5 we describe two main streams in the economic growth theory that attempt to extend human capital to include health as an input factor. In the last section, we conclude on the importance of human capital as a determinant of economic growth.

2.2 Human capital as a factor of production

In the last decades economic theory has deserved an increasing attention to the economic growth and convergence process[3]. Macroeconomic analysis aiming to explain the role and impact of different factors on economic output is usually consensual on the main determinants of economic growth and convergence, focusing crucially on the accumulation of physical and human capital. Among many contributions in this area, the neoclassical Solow–Swan (1956) model is one key-reference and the departing point to explain growth. According to this model, physical capital accumulation and exogenous technological progress (seen as a public good) are the driving forces of economic growth in the long term analysis. Diminishing returns of factor inputs (namely capital and labour) and decreasing economies to scale of the total productive factors will induce faster growth in countries with lower stock of capital (the less developed economies) comparatively to countries with higher capital stock (the most developed economies). In other words, poorer countries grow faster than the richer ones and this is related to the β -absolute convergence hypothesis. Another property of the neoclassical model is that, in the long run, all countries will converge to the same steady-state income level, holding the initial conditions constant. The Solow-Swan model was tested in the empirical literature but it was unable to explain the ever growing distance between the rich and poor economies. Absolute convergence was only found between countries with similar characteristics or between regions of the same country.

The incapacity to explain the discrepancy between what theory predicts and what empirical evidence shows, contributed to the development of new theories. It is still in the eighties that new growth theories emerged, known as the endogenous growth models[4], that consider technological progress to be endogenous to the growth process, generating increasing returns to scale with important externality effects spread out in the economy. The neoclassical growth model is extended to include human capital having

[3] See, for instance, Sala-i-Martin (1996).

[4] It is mainly after the 80's that an increasing interest on the convergence debate emerged. As Sala-i-Martin (1996) notes, the convergence analysis can be seen as a test to neo-classical growth model explaining its validity. On the other hand, it is due to the relative recent availability of aggregate data on country-level that made international comparisons possible.

increasing returns properties that compensate the decreasing returns of physical capital[5]. One important contribution of the endogenous growth theories is that they are able to reconcile the economic growth processes with different steady states that characterize each country/economy. Since technical progress is seen as an economic process itself, with economic determinants (Howitt, 2005), it is expectable that different economies with different structural conditions will have distinct steady-state levels. As a consequence, the rate of economic growth will depend on the distance of each country to its respective steady state level, which is known in the growth literature as the β -conditional convergence hypothesis. Countries will converge to different steady-states described by idiosyncratic structural characteristics. Convergence is not the rule as the neoclassical theory assumes, but conditional on structural characteristics which have to be taken into account in the growth process.

Several endogenous growth models can be distinguished, depending on the growth sources that are considered: physical capital, human capital, public infrastructures or technological innovation. Among these models, Romer (1986) and Lucas (1988) make two major contributions. Romer (1986) considers a production function with increasing returns to scale due to the positive externalities emanating from the physical capital accumulation. Human capital was first introduced in endogenous growth models by Lucas (1988). According to this author, human capital must be seen as a cumulative variable with positive externalities, and as the main driving force of a country's growth performance. The main idea is that more educated individuals are more efficient and more productive in their work. Education enhances productivity, not only through the knowledge or competencies incorporated on individuals but also through the stimulation of physical investment and adoption of technological development (Sianesi and Reenen, 2003).

Although the traditional Solow-Swan growth models underestimated the role of education, Mankiw, Romer and Weil (1992) – MRW hereafter – showed that it is possible to extend the model to incorporate human capital as a production factor. However, contrary to new growth theories, the MRW approach doesn't take into account that education can have additional indirect effects (externalities) on growth. In

[5] According to Bassetti (2006), while for endogenous growth theories human capital plays a crucial role, it is secondary in the neo-classical models.

spite of that and according to Bassetti (2006), with this approach MRW showed that the data was fairly consistent with the underlined assumptions of the model.

In fact, most of the theoretical and empirical research that analyzes the determinants of economic growth generally follows one of the two approaches: either the augmented neo-classical model or the endogenous growth framework. This distinction is also related to different human capital concepts: while for the augmented neo-classical growth model it is the stock of human capital that matters, in the new endogenous growth theories it is its accumulation (level) that plays a crucial role. Although departing from different assumptions and theoretical developments that tend to favour the preference for new growth theories, the empirical literature is mixed and there is no agreement on what is the most appropriate approach to measure the impact of human capital (education) on economic growth: the initial stock or the human capital accumulation over time. Sianesi and Reenen (2003) show similar empirical evidence on the role of human capital on economic growth, whatever the approach adopted. The same argument is also discussed by Barro and Sala-i-Martin (2004) considering that both the neo-classical model and models of technological diffusion can explain empirical facts as well. However, it is important to have in mind that methodological problems such as omitted variable bias, endogeneity problems, sample selection bias and restrictions on the availability of data may be responsible for these results[6].

[6] In fact, given the restrictions on the availability of data, most studies use average years of schooling or enrolment rates as human capital proxies. However, these are quantitative measures of human capital that may be inappropriate to capture the qualitative effects of education on economic growth, mainly in developed countries.

2.3 Health as a factor of production

Health as a component of human capital has generated a great interest in the literature both from the theoretical point of view and empirical perspective[7]. If traditionally human capital is associated to the worker's education/skills, more recently it has assumed a broader notion to include health factors. The idea that human capital accumulation could be improved by investing in the population's health was already advanced in the sixties by Schultz (1961) and Mushkin (1962) and gained definitively relevance after Grossman's (1972) pioneer work. Indeed, Grossman (1972) was the first to consider explicitly this issue, relating a higher preference for health (as a consumption good) to more educated individuals. According to the same author, health can be also seen as a capital good, since the production of health determines how much time is spent in labour. Healthier individuals are less likely to be absent at work due to illness and so they are more productive. In this context, health status is an important part of human capital, directly linked with education, and it can be defined as an individual's health stock[8]. Like physical capital, health capital depreciates over time but individuals can invest to improve their health status.

At a macroeconomic level, the idea that human capital incorporates not only education but also health status of the population is more recent. Some pioneer studies that relate health conditions with per capita income are due to Preston (1975), who showed a positive link between national income levels and life expectancy, and reports of the World Bank (World Bank, 1993). Initially the focus was on the role of health to less developed countries (LDC) as a mean to escape from the poverty trap[9]. Since then, there was an increasing interest in the economic growth literature, mainly to analyze differences between rich and poor countries' performances. Several studies showed that initial health conditions are the most robust predictors of subsequent growth, having a

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[7] For a review of the literature, see for instance Becker (2007).

[8] WHO Constitution of 1948 defines health as "a state of complete physical, social and mental wellbeing, and not merely the absence of disease or infirmity". However, in a context of health promotion, the WHO has assumed a more objective notion of health, being considered as "a resource which permits people to lead an individually, socially and economically productive life". In this perspective, health must be seen as "a positive concept emphasizing social and personal resources as well as physical capabilities" (WHO, 1998). In the economic literature, health is often measured by life expectancy at birth or at other age.

[9] See Sala-i-Martin (2005), among others.

higher explanatory power than the initial level of education (Barro, 1996; Knowles and Owen, 1997).

To a lesser extent, in the last years the analysis has also been extended exclusively to rich countries. In fact, in what concerns the most developed countries (OECD countries for simplicity) health is also a central issue both at academic and political debates because of two main trends that affect especially this group of countries. One is the ageing of the population (explained by higher life expectancy and lower fertility rates) and the other is the higher prevalence of chronic diseases (major cause of mortality and morbidity in the OECD countries (WHO, 2008)). Higher average ages of the working population in countries with longer life expectancies may have negative consequences on resistance to change or innovation capacity, which is the driving force of economic growth according to new growth theories. On the other hand, the increasing incidence of chronic diseases, that affect not only the elderly but also individuals still at working age, causes incapacity and absenteeism and, consequently, lower productivity that affects negatively economic growth. Lastly, it is also important to note the severe challenge that ageing population represents to the social security systems and the pressure it causes on public finances.

The consideration of the health dimension as a component of human capital implies the need to measure it. However, this is a very complex task when compared with other forms of human capital. First, it should be noted the ambiguity of the concept and, consequently, the difficulty to choose which are the more adequate proxies to use. In fact, this is a critical problem specially for analyzing most developed countries. Efforts to identify health proxies are strongly limited by the availability and quality of data which constitutes a severe restriction for empirical research and international comparisons. This is the main reason why the most common used measures of population health status are life expectancy at birth[10] or at different ages, and mortality rates. However, as Wilkie and Young (2009) note, the use of raw mortality and longevity indicators may underestimate health outcomes, mainly because health spending in developed countries is increasingly focusing on improving the quality of life. According to the same authors, other important and even more interesting measures of health outcomes in rich countries would be the use of indicators that would express

[10] Life expectancy can be considered as the health capital of one person and it is defined as the number of years a person is expected to live at birth or at various ages (for instance at 65 years of age).

also more qualitative aspects of the health care system, such as cancer survival rates. However, once more the lack of data does not allow international comparisons. As a proxy for these qualitative aspects, some authors, like Or (2000), use a premature mortality indicator- “potential years of life lost” – that is available for OECD countries. Nevertheless, in the OECD Health Data this indicator doesn’t consider survival after 70 years old in the OECD Health Data, which strongly restrains its application since a large amount of health resources in rich countries are concentrated at the elderly population (Joumard *et al*., 2008[11]). Lastly, we should take into account that, like education, health conditions generally have long term effects and therefore their economic impact is more difficult to estimate.

[11] Given these limitations on the availability of data, these authors consider that mortality and longevity indicators are still good proxies of the health status of OECD population health status.

2.4 Channels through which health affects economic growth

Assuming a broader notion of human capital in economic growth analysis implies the need to disentangle the relations between its components (education and health[12]) and economic performance, which is a complex task because of the reverse causality between them. Human capital (education and health) improvements enhance economic growth but economic growth also contributes to increase the levels of human capital through improvements in education and the health sector[13]. In this section we are interested in highlighting how improvements in the health status of the population have a positive impact on economic performance through different mechanisms widely discussed in the literature. Following Howitt (2005)[14], we can identify five main channels:

(i) Productive efficiency

Health, like education, is a conditioning factor of an individual's productivity and efficiency. There is empirical evidence (Schultz, 2005; Cai and Kalb, 2006) that healthier workers have more physical and mental energy, being more creative and productive. Health also affects labour supply since health problems cause many times *absenteeism* at work (Bloom *et al.*, 2001; Bloom and Canning, 2008) but also *presenteeism*, a relatively recent concept meaning those individuals that even feeling too ill still go to work although being less productive (Productivity Commission, 2006). According to Edwards and Greasley (2010), the absenteeism average rate in Europe (EU27 and Norway) is between 3% and 6% and has an estimated cost near 2.5% of GDP. This absenteeism is explained chiefly by health problems, with musculoskeletal and respiratory problems being the two major causes. Conversely, healthier workers have higher chances of receiving skill upgrading investment from the part of the firms they work. Usually more educated individuals are the ones who have better jobs, with

[12] There are well established links between education and health documented by several authors like Albert and Davia (2007), Currie (2009), Cutler and Lleras-Muney (2006; 2010).

[13] See, for instance, Adams *et al*. (2003) for an analysis of feedback effects between these dimensions.

[14] See, for instance, Canning and Sevilla (2002), Bloom and Canning (2005) and Suhrcke *et al*. (2005), for a similar description of the channels of transmission between health and economic growth.

higher incomes and safer work conditions and so they are likely to invest more on health (Bloom *et al.*, 2001).

(ii) Life expectancy

One important outcome of health status improvements is the raise of life expectancy, which has consequences on education and investment/saving decisions. It makes investment in education more attractive and at the same time it is an incentive to save more for retirement, since individuals expect to live longer (Kalemli-Ozcan *et al*., 2000). Therefore an increase of life expectancy should raise schooling qualifications and saving rates[15]. An increase of life expectancy has also effects on the demographic structure of the population. By reducing infant mortality, a higher life expectancy will be reflected on a raise of the proportion of working age population. However, in the long term it is expectable that a decrease in the fertility rate will have the opposite effect, so the final result will depend on the predominance of these two forces[16]. In what concerns the OECD countries, the evidence shows that the prevailing factor is the decrease in fertility rate leading to a higher dependency ratio and lower proportion of the working age population[17].

(iii) Learning capacity

At a microeconomic level many studies empirically support the idea that an improvement on health status and nutrition are responsible for better cognitive capacities and educational outcomes. Miguel (2005), using panel data methods for rural areas of Kenya and India, shows that both children health status and parent's death have an important impact on education, namely on school attendance. Case *et al*. (2005), using a panel data for the Great Britain, analyzed the impact of health (measured by prenatal and childhood health) on educational outcomes and found a strong relation

[15] It is expectable that increased life expectancy at 65 years old will influence consumer's life-cycle behaviour, leading to higher saving rate in the "middle age", since individuals probably will live more years being retired.

[16] For a discussion on this issue and possible consequences on economic growth, see Prettner *et al*. (2010).

[17] This is in fact a most relevant issue that justifies an increasing interest by policy decision makers. On this issue, see for instance a special report by The Economist (2009).

between poor children’s health and lower educational returns. In general it is expected that healthier people have higher learning capacity explained not only by showing less absenteeism at school or at work but also for being more capable to assimilate and accumulate more knowledge. So it is expectable that healthier children will have better education and will be more productive in the future. As Bloom (2006) points out, the health of other family members and maternal health, which is closely connected with child health (Currie and Moretti, 2003), also affects educational performance.

(iv) Creativity

Health improvements induce better educational achievements, which are likely to have additional effects on the country’s creativity and innovation activity. This idea is supported by Nelson and Phelps (1966) who showed that educational improvement speeds technological diffusion since educated individuals are likely to become good innovators and to be more flexible to technological changes. Innovation and technical progress are highly dependent on the educational level where health has an important role to play for achieving higher standards in these sectors. McCain and Mustard (1999; 2002) also evidence that better maternal and childhood health is related to a better capacity to deal/manage with emotional stress. In this context, it is assumed that healthier workers are more able to have positive reactions to change, which is a determining factor for a successful change implementation. Healthier and more educated workers will be more receptive to technological change and innovation processes.

(v) Inequality

Investment on human capital qualification is one important explaining factor of wage differentials[18]. Having this in mind, promoting health can be seen as a vehicle to reduce income inequalities, since health policies will affect more the less favoured population. Considering that better health is related to better education achievements and labour productivity, it is expectable that a healthier individual with higher school enrolment will be more productive and will have more job opportunities to explore with

[18] According to Mincer (1994: 8), human capital investments consider, beyond years of schooling, “formal and informal job training and learning as well as job mobility involving search on and off the job”.

higher wages[19]. As Howitt (2005) notes, a reduction of income inequality will allow a higher proportion of individuals to finance their education and their health needs, being therefore more able to improve their economic situation. Since the link between health and income is reversal, a decrease of income inequality will cause a reduction on health inequality[20]. Investing in the health sector is a way to reduce income inequalities, to increase labour productivity and therefore growth.

Having all these linkages in mind it is important to notice that the health sector gains a growing share in the economy especially in the most developed countries. In fact, the health sector (including social services) is responsible for an increasing proportion on total employment in the OECD countries, as it is shown in Figure 2.1 and Figure 2.2 in the Annex 2.A. The average employment share in this sector is close to 10% in the OECD countries, with the highest records registered in the Scandinavian countries (20% in Norway). The employment share of the health sector is relatively low in Portugal, only 5.9%, showing that improvements can be made for the sake of the wellbeing of the population and better economic performance. The health sector is important not only for improving labour productivity and personal wellbeing but for opening new employment and business opportunities with substantial multiplier effects on economic growth.

[19] This result is corroborated by Psacharopoulos and Patrinos (2004) whose empirical results show that the average rate of return to one more year of schooling is 10%. These authors also point out that the highest returns are recorded for low-income and middle-income countries.

[20] This idea is discussed by Deaton (2003) that distinguishes the absolute income hypothesis – which considers that health is affected by absolute income level and not by income inequality – from the relative income hypothesis – health also depends on income inequality.

2.5 Modeling growth to include human and health capital

The economic literature that studies the macroeconomic impact of health on economic growth usually follows two different methods: the aggregate production function approach or the economic growth framework based on the regression analysis. The first approach carries out an accounting decomposition of the different sources that affect aggregate output and was primarily followed by Klenow and Rodríguez-Clare (1997) and more recently by Bloom and Canning (2005)[21]. Some of the restrictions of this method are that it imposes technology parameters based on microeconomic evidence[22] and it assumes an aggregate production function that works in a similar way as the production function at the firm level. The economic growth regression approach (which is also based on the production function) has a more solid theoretical background than the production function accounting decomposition approach and it is in fact the most used in the broader literature of economic growth. Following this approach, many studies show that the initial levels of population health are a significant predictor of future economic growth[23].

In the following sub-sections we present two different growth models that attempt to extend human capital to include health as an input factor of economic growth. At the same time they illustrate two alternative approaches: the MRW version of the Solow Swan model extended to health and a model of innovation based on the Schumpeterian growth theory.

2.5.1 The MRW (1992) model

The growth model

Empirical research that uses the growth regression approach traditionally follows the extended Solow-Swan model as proposed by MRW (1992)[24]. As Islam (2003)

[21] In this study, based on a panel of countries for the period 1965-1995, the authors show that health in the form of adult survival rates has a positive and statistically significant contribution to aggregate output.

[22] These parameters are used to calibrate the size of the effects at the aggregate level. For further reading, see Bond *et al*. (2001).

[23] Among these studies we can refer Barro (1996), Bloom *et al*. (2004) or Soukiazis and Cravo (2006).

[24] See, for instance, Knowles and Owen (1997), Rivera and Currais (1999a; 2004) or Soukiazis and Cravo (2006).

points out, with this version of Solow's model, MRW showed that it is possible to reconcile sustained growth rate differences between countries. From the theoretical point of view, this model reflects the conditional convergence hypothesis, showing that the Solow model only predicts absolute convergence in special conditions. The model assumes a Cobb-Douglas aggregate production function defined as[25]:

$$Y(t) = K(t)^{\alpha} E(t)^{\beta} H(t)^{\eta} [A(t)L(t)]^{\mu} \qquad (2.1)$$

where $\mu = 1 - \alpha - \beta - \eta$, with $\alpha, \beta, \eta > 0$ and $0 < \mu < 1$.

In this model *Y* denotes total income (aggregate output), *K* is the stock of physical capital, *L* is labour and *A* the technology level; *E* and *H* represent the stock of human capital, education and health, respectively.

A central assumption of the model is that *L* and *A* grow at a constant and exogenous rate, *n* and *g*, respectively, given by $L(t) = L(0)e^{nt}$ and $A(t) = A(0)e^{gt}$.

The model also assumes that output can be used for consumption or saving and that it is the proportion of the saved output ($S = sY$) that gives raise to investment. Physical capital depreciates itself at a constant rate δ , $\dot{K} = sY - \delta K$ and human capital (education and health) are also subject to the same depreciation rate, δ .

Dividing both sides of equation (2.1) by *AL*, we can express the production function in terms of effective labour units:

$$y(t) = k(t)^{\alpha} e(t)^{\beta} h(t)^{\eta} \qquad (2.2)$$

where $y = \frac{Y}{AL}$, $k = \frac{K}{AL}$, $e = \frac{E}{AL}$ and $h = \frac{H}{AL}$.

The dynamic evolution of the economy (growth rates) is determined by the following equations:

$$\dot{k}(t) = s_k y(t) - (n + g + \delta)k(t) \qquad \text{physical capital accumulation} \qquad (2.3a)$$

[25] The description of the model follows Rivera and Currais (2004).

$$\dot{e}(t) = s_e y(t) - (n + g + \delta)e(t) \qquad \text{labour growth} \tag{2.3b}$$

$$\dot{h}(t) = s_h y(t) - (n + g + \delta)h(t) \qquad \text{human capital accumulation} \tag{2.3c}$$

The steady state conditions of the productive factors are given by:

$$k^* = \left[\frac{(s_k)^{1-\beta-\eta} (s_e)^{\beta} (s_h)^{\eta}}{n + g + \delta} \right]^{\frac{1}{1-\alpha-\beta-\eta}} \tag{2.4a}$$

$$e^* = \left[\frac{(s_k)^{\alpha} (s_e)^{1-\alpha-\eta} (s_h)^{\eta}}{n + g + \delta} \right]^{\frac{1}{1-\alpha-\beta-\eta}} \tag{2.4b}$$

$$h^* = \left[\frac{(s_k)^{\alpha} (s_e)^{\beta} (s_h)^{1-\alpha-\beta}}{n + g + \delta} \right]^{\frac{1}{1-\alpha-\beta-\eta}} \tag{2.4c}$$

Replacing *k*, *e* and *h* by their respective steady state conditions in equation (2.2), we find the steady state output per unit of effective labour:

$$y^*(t) = \left(\frac{(s_k)^{1-\beta-\eta} (s_e)^{\beta} (s_h)^{\eta}}{n+g+\delta} \right)^{\frac{\alpha}{1-\alpha-\beta-\eta}} \left(\frac{(s_k)^{\alpha} (s_e)^{1-\alpha-\eta} (s_h)^{\eta}}{n+g+\delta} \right)^{\frac{\beta}{1-\alpha-\beta-\eta}} \left(\frac{(s_k)^{\alpha} (s_e)^{\beta} (s_h)^{1-\alpha-\beta}}{n+g+\delta} \right)^{\frac{\eta}{1-\alpha-\beta-\eta}} \tag{2.5}$$

Given that $y = \frac{Y}{AL}$, and taking into account equation (2.5), we can determine the steady state per capita output (or per effective labour unit), given by:

$$\ln\left[\frac{Y(t)}{L(t)}\right] = \ln A_0 + gt - \left(\frac{\alpha + \beta + \eta}{\mu}\right) \ln(n + g + \delta) + \frac{\alpha}{\mu} \ln(s_k) + \frac{\beta}{\mu} \ln(s_e) + \frac{\eta}{\mu} \ln(s_h) \quad \text{with}$$

$$\mu = 1 - \alpha - \beta - \eta \tag{2.6}$$

This equation shows that there exists a direct relation between the steady state per capita income and physical capital, education and health investment rates and an inverse relation between per capita income and active population growth.

Alternatively, solving (2.4b) and (2.4c) using s_e and s_h as a function of e* and h* and replacing in equation (2.6), we can define per capita income as follows:

$$\ln\left[\frac{Y(t)}{L(t)}\right]=\ln A_0+gt-\left(\frac{\alpha}{1-\alpha}\right)\ln(n+g+\delta)+\left(\frac{\alpha}{1-\alpha}\right)\ln(s_k)+\left(\frac{\beta}{1-\alpha}\right)\ln(e^*)+\left(\frac{\eta}{1-\alpha}\right)\ln(h^*)+\varepsilon(t) \qquad (2.7a)$$

Solving (2.4c) for s_h and replacing it in equation (2.6), we have:

$$\ln\left[\frac{Y(t)}{L(t)}\right]=\ln A_0+gt-\left(\frac{\alpha+\beta}{1-\alpha-\beta}\right)\ln(n+g+\delta)+\left(\frac{\alpha}{1-\alpha-\beta}\right)\ln(s_k)+\left(\frac{\beta}{1-\alpha-\beta}\right)\ln(s_e)+\left(\frac{\eta}{1-\alpha-\beta}\right)\ln(h^*)+\varepsilon(t)$$

(2.7b)

Therefore per capita income (or per effective labour unit) is explicitly determined by the population (or labour) growth, the saving (or investment) ratio, the human capital stock, and the health conditions.

The convergence approach

The convergence process relies on the following partial adjustment mechanism:

$$\frac{d\ln y(t)}{dt}=\lambda\left(\ln y^*-\ln y(t)\right) \qquad (2.8)$$

where $\lambda=(n+g+\delta)(1-\alpha-\beta-\eta)$ is the convergence rate.

Taking two different periods, this equation implies that

$$\ln y(t_2)=\left(1-e^{-\lambda T}\right)\ln y^*+e^{-\lambda T}\ln y(t_1) \qquad (2.9)$$

where $y(t_1)$ is the effective per capita income at the initial period and $T=t_1-t_2$ is the time period under analysis.

If we subtract $y(t_1)$ from both sides of equation (2.9), we obtain the convergence equation that can be written as follows:

$$\ln y(t_2)-\ln y(t_1)=\left(1-e^{-\lambda T}\right)\ln y^*-\left(1-e^{-\lambda T}\right)\ln y(t_1)$$

or

$$\ln y(t_2)-\ln y(t_1)=\left(1-e^{-\lambda T}\right)\left[\ln y^*-\ln y(t_1)\right] \qquad (2.10)$$

Equation (2.10) represents a partial adjustment process, showing that the greater the distance from the steady-steady income level the faster the growth of a specific country is. Replacing y^* by the expression found in (2.7b), we determine the expression for the long run income growth,

$$\ln\left[\frac{y(t_2)}{y(t_1)}\right] = \ln y(t_2) - \ln y(t_1) =$$
$$= \left(1-e^{-\lambda T}\right)\left[\ln A_0 + gt + \left(\frac{\alpha}{1-\alpha}\right)\ln(s_k) + \left(\frac{\beta}{1-\alpha}\right)\ln(e^*) + \left(\frac{\eta}{1-\alpha}\right)\ln(h^*) - \left(\frac{\alpha}{1-\alpha}\right)\ln(n+g+\delta) - \ln y(t_1)\right] \tag{2.11}$$

If the model to estimate is a dynamic panel data model, where $\left(1-e^{-\lambda T}\right)\ln A_0$ represents the country individual effects, constant over time, the equation to estimate is given by:

$$\ln y_i(t_2) - \ln y_i(t_1) = \left(1-e^{-\lambda T}\right)\ln A_0 + \left(1-e^{-\lambda T}\right)gt - \left(1-e^{-\lambda T}\right)\ln y_i(t_1) - \left(1-e^{-\lambda T}\right)\left(\frac{\alpha}{1-\alpha}\right)\ln(n+g+\delta) +$$
$$+ \left(1-e^{-\lambda T}\right)\left(\frac{\alpha}{1-\alpha}\right)\ln(s_{ki}) + \left(1-e^{-\lambda T}\right)\left(\frac{\beta}{1-\alpha}\right)\ln(e_i^*) + \left(1-e^{-\lambda T}\right)\left(\frac{\eta}{1-\alpha}\right)\ln(h_i^*) + v_{i,t} \tag{2.12}$$

where $v_{i,t}$ represents the error term, different across countries and over time.

Having in mind equation (2.12), the convergence equation is usually presented in a more simplified way:

$$\Delta \ln y_i(t) = \gamma + b \ln y_i(t-1) + u_i(t) \quad \text{with} \quad b = \left(1-e^{-\lambda T}\right) \tag{2.13}$$

Equation (2.13) reflects the absolute convergence hypothesis, with $b<0$. If we take into account structural factors (human capital, health status, institutions, trade, etc) that characterize the steady-state of different countries $\left(X^j\right)$, we can establish the conditional convergence hypothesis by the following equation:

$$\Delta \ln y_i(t) = \gamma_i + b \ln y_i(t-1) + c_j^{'} \ln X_i^j(t) + u_i(t) \quad \text{with} \quad b = \left(1-e^{-\lambda T}\right) \tag{2.14}$$

Having in mind the advantages already referred in adopting panel data estimation techniques, this is the approach used in most empirical studies in the economic literature, and this will be the approach to adopt in this study.

2.5.2 A Schumpeterian growth model based on innovation

In recent years endogenous growth models have also made theoretical advances to include health as an important human capital input. Howitt (2005)[26] proposes an endogenous economic growth model that highlights the several channels through which health can influence a country's growth pathway. This model also relies on a neoclassical Solow-Swan model of growth extended to include human skills accumulation and it assumes that the country's aggregate production function, that exhibits constant returns to scale, can be expressed by the following equation:

$$Y = \psi F\left(K, AS(1-\varepsilon)\right) \tag{2.1'}$$

where *Y* represents the Gross Domestic Product (GDP), *K* and *S* are the capital and the skills stocks, respectively, and *A* stands for the aggregate productivity; the parameters ψ and ε represent the productive efficiency and school attendance, respectively.

Equations (2.2') and (2.3') describe net investment and population growth behaviour:

$$\frac{dk}{dt} = \sigma Y - \delta K \tag{2.2'}$$

$$\frac{dL}{dt} = \eta L \tag{2.3'}$$

where the parameters σ, δ and η represent the saving rate, the depreciation rate and the population (labour) growth rate, respectively.

[26] Other references include van Zon and Muysken (2005) – who developed an endogenous growth model of the Lucas type extended to include demographic and epidemiological conditions – or Jamison *et al*. (2005) – that explored the hypothesis that health may be one of the potential endogenous sources of technology progress.

According to this model, net investment of skills depends on the number of persons that are enrolled in the learning process and on the amount of skills' depreciation that occurs with the death of people embodying skills, as equation (2.4') shows:

$$\frac{dS}{dt} = \lambda \varepsilon L - \phi S \tag{2.4'}$$

where the parameters λ, $\varepsilon(\varepsilon < \frac{1}{2})$ and ϕ represent the learning efficiency, the school attendance and the skill-adjusted death rate, respectively.

These first four equations represent a neoclassical model extended to the accumulation of skills.

The following four equations endogeneize the rate of technological progress, defining investment (*R*) as a proportion of the GDP that is spent on technology investments and that depends on a country's research intensity, $\rho(\rho < 1)$:

$$R = \rho Y \tag{2.5'}$$

Equation (2.6') below shows that the country´s technological progress depends on its domestic rate of innovation (*v*) and on its distance to the frontier $(A^* - A)$:

$$\frac{dA}{dt} = v(A^* - A) \tag{2.6'}$$

with A^* representing the global technological frontier.

Assuming that the country's frontier grows at a given rate g^*, we have:

$$\frac{dA^*}{dt} = g^* A^* \tag{2.7'}$$

The model also assumes that the innovation rate (*v*) is positively related to investment where μ is the research efficiency. On the other hand it is inversely related to the country's population (labour) size. The aim is to avoid that more populous countries would grow faster as a consequence of a population scale effect as it is shown in equation (2.8'):

$$v = \frac{\mu R}{A^{*} L} \tag{2.8'}$$

Following Howitt (2005), with this specification it is possible to identify the main channels through which health improvements affect economic growth, already referred:

- the effect of a better health on *productive efficiency* can be achieved by raising the value of the parameter ψ in equation (2.1') having a positive contribution to economic performance;
- through equation (2.4') it is expected that health improvements due to a raise of *life expectancy* will have a direct effect on the average skill level of the population through the impact on ϕ, the skill-adjusted death rate; on the other hand, an increase in *life expectancy* may have positive effects on the saving rate (σ) and school attendance (ε);
- better health conditions (through better nutrition and health care) play an important role in education achievements which are reflected in the model by raising the parameters λ - learning efficiency - and ε - school attendance - in equation (2.4');
- a better health status of the population is expected to have a positive impact on the research-intensity parameter (μ) in equation (2.8') and may also contribute to increase the research-intensity parameter (ρ), in equation (2.5');
- reducing income inequality plays a critical role in improving poor peoples´ health, by satisfying their basic needs and having better access to health care. On the other hand, it is shown in economic literature[27] that reducing income inequalities has an important positive impact on school attendance, which is reflected in this model by increasing the value of the parameter ε in equations (2.1') and (2.4').

The growth model we described above can still be reduced if we take into account that equations (2.3') and (2.4') – the population growth equation and the skills investment equation, respectively – imply that in the long run the stock of skills per unit of effective labour, given by $s \equiv S(1-\varepsilon)/L$, will converge to:

[27] See, for instance, Castelló-Climent (2005).

$$s = \frac{\lambda\varepsilon(1-\varepsilon)}{\phi+\eta} \tag{2.9'}$$

On the other hand, having in mind the first four equations of the model and equation (2.9'), the growth of the capital stock per unit of effective labour, given by $k \equiv K/AL$, can be described as follows:

$$\frac{dk}{dt} = \sigma\psi F(k,s) - (\delta+\eta+g)k \tag{2.10'}$$

where $g \equiv (dA/dt)/A$ is the technological progress rate.

On the other hand, if a country's relative productivity is given by $a = A/A^*$, we can assume that in the long run, the proportional income gap between a country and the world's technology leaders will be proportional to *a*. Given this definition for *a* and equation (2.7'), we get:

$$\frac{da}{dt} = a(g-g^*) \tag{2.11'}$$

From equations (2.1'), (2.5'), (2.6') and (2.8') we can define:

$$g = \mu\rho\psi F(k,s)(1-a) \tag{2.12'}$$

The model to estimate consists in a system of two main equations – (2.10') and (2.11') – where *g* is substituted by expression (2.12').

While accounting for the endogeneity of technical progress rate, Howitt's growth approach implies the use of predetermined parameters which reduces its applicability – a major problem faced by several endogenous growth model specifications (Ertur and Koch, 2010). Therefore in the empirical analysis measuring the impact of health capital on economic growth and convergence (at the OECD level or the Portuguese districts level in Chapters 3 and 5, respectively) we will follow the MRW approach.

2.6 Chapter concluding remarks

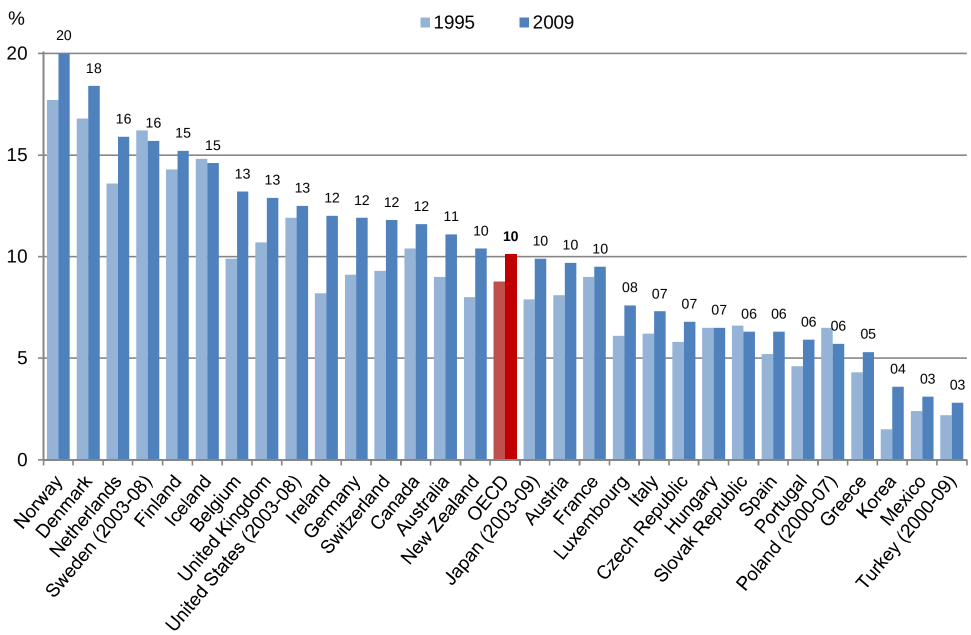
It is now consensual that health, along with education, is a determining factor of workers' productivity and, consequently, of per capita income growth. Therefore, for a more complete understanding of economic growth and the convergence processes, economic theory has incorporated health as a component of human capital.

However, efforts to measure the effects of health at a macroeconomic level are very complex, not only because of the reverse causality effects between income, health and education, but also because of additional difficulties on finding the more appropriate proxies to characterize health dimensions. These difficulties are particularly strong when the analysis focuses exclusively on most developed countries.

With this chapter our main scope was to explain how the two main theoretical approaches, the Solow-Swan neoclassical approach and the new growth theories, were adapted to the evolution of the human capital concept. At the same time we analyzed the two main empirical methodological approaches commonly used in the literature: the growth regression equation and the accounting approach. In what concerns the growth regression analysis, in fact the methodology most used, we expose two alternative modeling specifications: the MRW (1992) model and Howitt's (2005) model. While the former considers health dimension as an extra input – and so called "the augmented Solow-Swan model" – on the production function and highlights its impact on the level of output, the later takes into account that higher levels of human capital (education and health) will have spillover effects on the innovation rate and, consequently, on the growth rate of productivity. Specifically, the description of Howitt's (2005) approach allow us to a deeper understanding of how the linkages between human capital and economic performance may work and how they contribute to enhance further economic gains. Nevertheless a major problem faced with this model (and common to other endogenous growth model specifications) is its reduced applicability in the empirical analysis, which explains why a great part of empirical analysis follows the MRW approach.

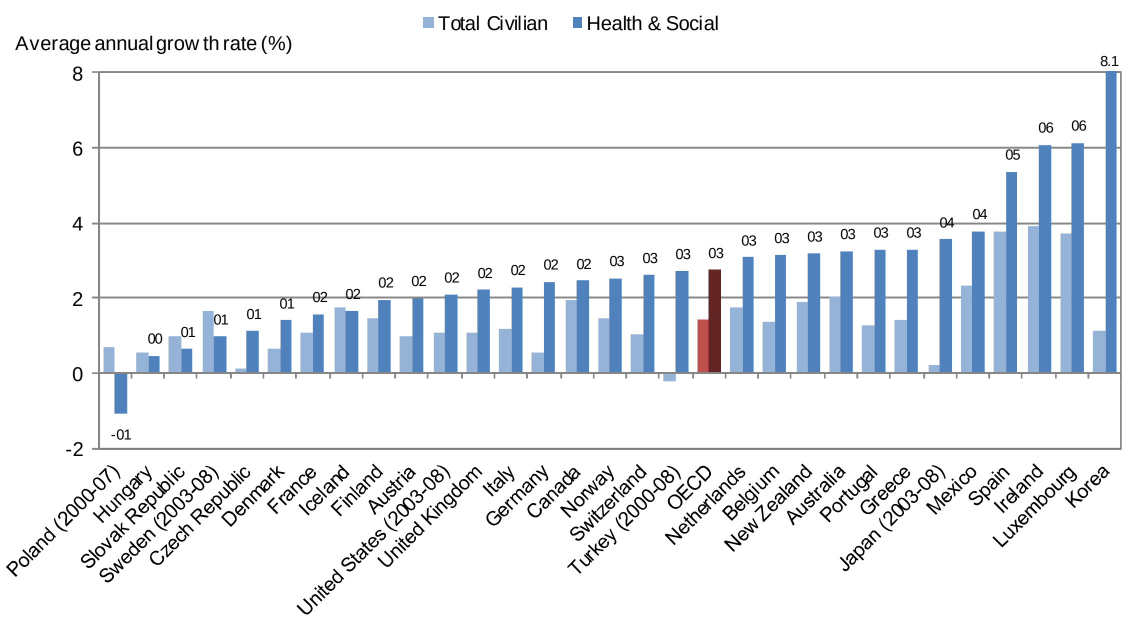
Annex 2.A.

Figure 2.1 – Employment in the health and social sectors as a share of total civilian employment, 1995 and 2008 (or nearest year available)



Source: OECD (2011a).

Figure 2.2 – Employment growth rate in the health and social sectors compared with all sectors in the economy, 1995 to 2008 (or nearest year available)



Source: OECD (2009a).

Chapter 3

Health Conditions and Economic Growth: Evidence from the OECD Countries

* An initial version of this Chapter was presented at the XXIII International Congress on Applied Economics – ASEPELT, in Covilhã, in June 2009. We are grateful to the participants for their helpful comments and suggestions.

It is available in (Ed.) Manso, J.P. e Monteiro, J. (2009), *Anais de Economia Aplicada 2009.*

3.1 Introduction

As it has been discussed in the previous chapter, health plays an important role on economic growth through many channels. Improved health cannot only contribute to a better economic performance at an individual level but also at an aggregate level affecting the whole economy[28]. On the other hand, a poor health status of the population represents a loss of human capital potential and, consequently, of the economic potential. In this way, investment in health must be seen not only as a social benefit but also as a key factor to economic growth.

Albeit the interest of the impact of health on economic growth (and convergence process), most of the economic literature in this area considers differences between rich and poor countries but less research is dedicated to the developed countries (Suhrcke *et al*., 2005; Suhrcke *et al*., 2006). Additionally, while for less developed countries empirical studies are consensual on a positive and significant relation between economic growth and health improvements, the same is not true for rich countries. According to several authors (Tompa, 2002; Suhrcke and Urban, 2006), these unclear results can be in part a consequence of the use of conventional health proxies such as life expectancy or infant mortality rates. If there is more consensus in the use of these proxies when analyzing developing countries, other variables can be more relevant when developed countries are concerned. These authors suggest the use of proper health proxies, such as cardiovascular disease mortality rate of active population, mental diseases or morbidity indicators. Among developed countries these indicators show greater variability and so they can better reflect the efficiency of the health system.

The aim of this chapter is therefore to analyze the contribution of the extended notion of human capital (including both human qualifications and health) on economic growth, considering a sample of 22 OECD countries. Bearing in mind that OECD countries are characterized by having higher education levels (although yet with large differences between them), we think that to a better understanding of the mutual influence of human capital qualifications and health on economic growth we should use different proxies from the traditionally ones to capture the health conditions that are more specific to this group of countries. At the same time, analyzing the impact of some of the most pertinent health indicators will allow us to describe the main trends on

[28] See, Bloom and Canning (2005) or Wilkie and Young (2009), among others.

health of the OECD countries. With this purpose we examine the impact of cerebrovascular disease mortality, life expectancy at 65 years old, average length of staying for acute care (days), among other indicators. An augmented Solow growth model is used that considers human and health capital as conditioning factors to growth. Panel data estimation techniques are applied to estimate growth equations, for a sample of 22 OECD countries from 1980 to 2004.

The chapter is organized as follows. Section 3.2 describes the reverse causality effects between human capital qualifications and health and explains how the two dimensions and per capita income can establish a virtuous circle. In section 3.3 we review some of the existing literature that focuses exclusively on developed countries. In section 3.4 we explain the growth model and the estimation approach suitable to panel data to obtain consistent estimates. The empirical results are presented and discussed in section 3.5. The final section concludes suggesting some policy implications.

3.2 Links between health, human capital and economic growth

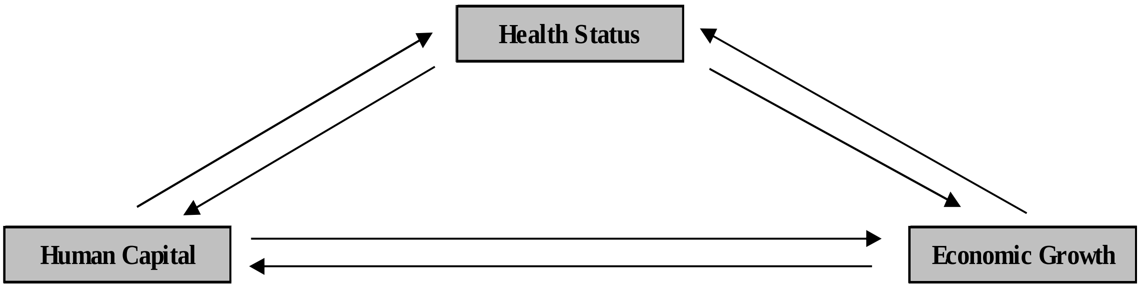
As already referred in Chapter 2, there are several links through which health contributes to improve standards of living measured by per capita income. One important link is through education. In this chapter we give special attention to the interrelations between education and health (that run in both ways) and the role they play in explaining economic growth. If it is true that health improves growth mainly through its effects on education and productivity, it is also well recognized the crucial role of education on the development of individual psychosocial competencies (crucial to the promotion of health literacy and the adoption of healthy lifestyles) and in reducing income and health inequalities (Ricci and Zachariades, 2009; Currie, 2009; Cutler and Lleras-Muney, 2010).

The relationship between education and health has been shown by several authors (Cutler and Lleras-Muney, 2006; Albert and Davia, 2007; Silles, 2009) usually exploring three channels: productive efficiency, allocation efficiency and time preference. The first approach states that more educated people are more efficient in the use of healthcare services. Under the second approach, education is considered the driving force of health improvement: more educated individuals are more conscious of the negative impact of their risk behavior and tend to invest more time and resources on healthcare. According to the time preference hypothesis, improvements on individuals' outlook in the future (which means an increase of the present discounted value of future lifetime utility) make people more likely to invest in protecting that future.

Taking into account these interrelations, it is expectable that at a macroeconomic level both education and health will be a driving force of economic growth with positive externalities in the rest of the economy. As Soukiazis (2008) explains there may exist a mutual causation tendency between income, health and human capital with feed-back and spillover effects. This reciprocal interrelation can give rise to a cumulative causation process, with health improvements leading to higher human capital accumulation and therefore higher economic growth, and the process continues to expand in a virtuous circle[29] as it is explained in Figure 3.1:

[29] Contrasting to situations characterized by poor health and poor economic growth leading to poverty trap. See, for instance, Sala-i-Martin (2005).

Figure 3.1 – Causality Effects between Heath, Human Capital and Economic Growth



Source: Soukiazis (2008).

As it can be seen, health has direct effects on human capital and economic growth due to better education and higher productive efficiency. On the other hand, better education contributes to improve health conditions through two channels: at the individual level more educated people invest more on health care and live in healthier conditions, at the aggregate level, societies with higher levels of educational standards invest more on research and development in the health sector. Another causation effect is from economic growth to health and human capital. As countries improve their economic performance they have the capacity to invest more on education, research and development (R&D) activities and health services. This cumulative causation process may be characterized by increasing returns to scale properties and positive externalities stemming from human capital and health sectors that turn the process self-expanding.

However, we should also take into account some adverse factors/tendencies that may challenge this virtuous circle. It is well known the severe magnitude and impact that chronic diseases have (especially) in most developed countries, being responsible for high levels of morbidity and mortality[30]. Among these diseases, stroke and other cerebrovascular diseases, diabetes and cancer are the main causes of deaths in high-income countries (WHO 2008; 2008a). Moreover, these diseases don’t kill just the elderly; they affect more and more lower age groups, with all the drawbacks on labour supply, especially in a context of increasing ageing population in the OECD countries.

[30] The chronic diseases do represent a serious health problem that OECD countries have to face. As Anderson *et al*. (2007) point out, five of the most common chronic diseases (including diabetes, chronic lower respiratory disease, heart disease, hypertension, cancer, and HIV infection) are responsible for approximately half to two-thirds of deaths in most high-income countries. Using 2004 OECD health spending data, the authors analyze the burden of chronic disease, which makes up 80 per cent of most OECD countries’ health care use.

Although directly linked with age, the magnitude of these diseases on more developed countries also reflects the higher prevalence of non-healthy lifestyles in this group of countries[31].

In fact, in what respects more developed countries, the relationship between economic performance and health is very complex and still a matter of some controversial. While there should be a direct association between per capita income and health improvements through a better access to health care, there are some aspects of the whole economy performance that may work as health risk factors, especially during economic upturns, and that can contribute to a negative performance of some health indicators (namely, those related with mortality rates by specific causes).

The analysis of the association between economic performance and mortality rates was first studied by Brenner (1971) who provided empirical evidence on a negative relation between per capita GDP and risk mortality and a positive relation between the variability of GDP per capita and mortality risk[32]. The negative effects of economic fluctuations concerned mainly the poorest segment of the population and became known by the Brenner's hypothesis[33]. Since this pioneer study, other studies, from Brenner himself (1979)[34] but also other more recent contributions (such as, Ruhm, 2000; Laporte, 2004; Tapia Granados, 2005; Ruhm and Gerdtham, 2006) – applying more complex tools to time series analysis – contributed to an interesting debate around the effects of economic growth on health. Ruhm (2000), using fixed effects models for 50 states and the District of Columbia for the period 1972-1991, finds a procyclical variation (stronger for individuals aged 20-44 years old) between mortality rates for specific causes (with the exception of suicides). The author considers that his findings highlight the importance of time costs of medical care, healthy lifestyles and job related health effects. Empirical evidence from Laporte's (2004) study, using data for the USA

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[31] According to the WHO (2009), more than 30% of cancer could be prevented by modifying or avoiding key risk factors.

[32] The study analyses the relationship between economic change and heart diseases mortality in New York State and the United States over the period 1900-1967.

[33] According to the author, this phenomenon may reflect the fact that health harmful effects of economic instability only correspond to higher mortality rates some years later.

[34] In this study, Brenner (1979) confirms that economic recessions and subsequent periods of rapid economic growth are associated with a deceleration in mortality for England and Wales, which is in line with previous findings for the United States.

for the period 1948-1996, is also in line with Ruhm's (2000) results showing that unemployment reduce aggregate mortality risk. Tapia Granados (2005), using data for the USA economy during the 20th century – and using methods that account for the nonstationarity of the variables – finds that economic expansions are directly linked with mortality, with the exception of suicides. The author also notes that this phenomenon tends to be more pronounced in recent years for women and non-whites.

In what concerns the OECD countries, Ruhm and Gerdtham (2006) also found evidence that better economic conditions are associated with an increase of total mortality rates by several sources of death, with the exceptions of deaths from cancer, suicides and homicides. According to the authors, this procyclical mortality behavior is explained in a great part by the fact that economic activity is positively associated to higher levels of alcohol and tobacco consumption, reduced physical activity and worse diet and, consequently, obesity – behaviours that may reflect higher time prices – with all the harmful effects on health. Moreover, higher economic activity reflects in higher industry and traffic-related atmospheric pollution and it may be responsible for increased stress problems related to a stronger work pace and work time[35]. According to Tapia Granados (2005), all these factors may be responsible for the precipitation of deaths of persons suffering already from chronic diseases. Finally, as the same author refers, in periods of economic expansion industrial injuries and traffic accidents are more likely.

Another important aspect to notice is that the procyclical mortality fluctuation is associated with the social insurance system. Ruhm and Gerdtham (2006) found empirical evidence of a larger procyclical mortality fluctuation in countries with relatively weak social insurance protection (proxied by public social spending as a share of GDP). These results are in line with empirical findings of Nolte and McKee (2008) that analyze the contribution of the healthcare systems in explaining the evolution of avoidable mortality[36] in the United States and in eighteen industrialized countries between 1997/98 and 2002/03. The authors show that the decline in amenable mortality

[35] See Tapia Granados (2005) or Ruhm and Gerdtham (2006) for an analysis of the main mechanisms between economic activity and health.

[36] The concept of avoidable mortality was first developed by Rutstein *et al*. (1976) and refers to deaths that can be avoided by the implementation of adequate preventive strategies or therapeutic treatments. In their study, Nolte and McKee (2008) analyze trends in deaths considered amenable to health care before the age of seventy-five.

in all countries averaged 16 percent over that period, with the exception of the United States with a decline of only 4 percent. As the authors highlight, healthcare system has in fact an important role not only in treating people but also in developing strategies for the prevention of diseases.

In spite of all the challenges referred before, we can say that there is evidence that health improvements go along with economic growth, mainly through higher levels of education, higher investment in R&D and the development of health-related technology (Ricci and Zachariades, 2009). So, it is expectable that rich countries – with higher levels of tertiary attainment – have more scientific production implying also higher advances in the health sector and medical science. However, the existence of other factors that act in the opposite direction – with a negative influence on the health status – like the higher prevalence of unhealthy lifestyles justifies the need to consider in the analysis different health proxies to capture the reality of this group of countries.

3.3 Literature review

It is mainly after the nineties that there is an increasing interest on the role of health on economic growth and convergence among most of the developed countries. Some studies try to replicate previous findings on less developed countries (Knowles and Owen, 1995; 1997); others aim to highlight characteristics that are more specific to rich countries[37]. Overall, although it is recognized the importance of including health capital in growth analysis, in what concerns rich countries, the empirical evidence on the positive impact of health on growth is mixed as the following literature review illustrates.

A seminal study in this area is due to Fogel (1994) that analyses the role of health conditions on the economic performance of United Kingdom using time series for the period 1780-1980. The author finds that health (proxied by life expectancy) and nutrition improvements have accounted for a 30% increase of Britain’s economic growth. However, Knowles and Owen (1995; 1997) in a cross-country analysis couldn’t find statistical significance of the same proxy for 22 OECD countries[38]. On the contrary, Arora (2001) also analyses the impact of life expectancy at different ages for ten industrialized countries over periods of 100-125 years, using cross-section analysis, and finds that health was responsible for an increase of their pace of growth by 30 to 40%.

Aghion *et al*. (2010) also analyze the impact of health on economic growth proxied by life expectancy – both in the form of the rate of improvement of health and in level of health – for OECD countries and for the period 1940-1980. Using cross-country panel regressions, they find empirical evidence of a positive and significant relationship between health and economic growth. However, the authors’ results also show that this positive association tends to weaken after 1960 which is interpreted as evidence that,

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[37] In this section we will restrict the literature review to studies that concern exclusively more developed countries which is relatively scarce when compared to the numerous studies that focus on less developed countries or consider both developing and rich countries. For a broader literature review, see for instance, Jack and Lewis (2009).

[38] The authors’ empirical results are reported for a full sample of 77 countries and also for a sub-sample of 55 less developed countries, over the period 1960 to 1985, and suggest a strong positive relationship between economic growth and health. Only when the model is estimated for the 22 high-income countries, the authors find that the health status parameter is not significant. They consider this result expectable, given the lack of variation in life expectancy over this sub-sample.

although a large share of the growth in life expectancy at birth is related to a reduction in mortality at old age, it is mostly the decrease in the mortality of individuals aged forty or less that significantly affects economic growth.

In a more recent study and using Johansen multivariate cointegration methodology, Swift (2011) analyzes the relationship between health and GDP for 13 OECD countries over the periods 1820–2001 and 1921–2001. The author's empirical evidence reveal a long run cointegration relationship between life expectancy and both total GDP and GDP per capita for all of the countries included in the sample. The results show that a 1% increase in life expectancy will lead to a 6% increase in total GDP in the long run and 5% increase in GDP per capita. The author also finds a significant influence of total GDP and GDP per capita on life expectancy for most countries.

Using a different proxy for the health status – the adult survival rate – and cross-country analysis, Bhargava *et al*. (2001) find an important link between health and economic growth in poor countries, but are unable to replicate this result when only developed countries are considered.

Rivera and Currais (1999, 1999a, 2003) use health expenditure as a share of GDP as a proxy for health and panel data methods for OECD countries[39]. These studies show a significant positive effect of this expenditure on income per capita and growth. Also Beraldo *et al*. (2005) use the same proxy to analyze its impact on growth applied to a panel of 19 OECD countries over the period 1971-1998. Using a production function approach and cross-country analysis, the authors show that the explaining power of health expenditure on growth (between 16 and 27%) is greater than the education expenditure (nearly 3%). Although they found statistically significant results, some authors (Tompa, 2002) argue that this proxy for health should be used with caution, since it is not a good measure of the efficiency of health systems and, on the other hand, the positive association between GDP and health expenditure may reflect a reverse causation.

In fact, different results are reported by Amaral (2007) and Hartwig (2008). Amaral (2007) in a study that covers the European Union (15) countries for the period 1980-2000, analyses the impact of human capital and health on the convergence process. Using a panel data approach, the author's empirical results show that both dimensions have a positive impact on the convergence process but, while fertility rate shows

[39] The first two studies cover the period 1960-1990, while the third study covers the period 1960-2000.

statistical significance, spending on health and education are not relevant. Hartwig (2008) uses a dynamic panel Granger causality framework to estimate the impact of health capital formation (proxied by health expenditure) of 21 OECD countries on economic growth and he doesn't find evidence of a positive effect in the long-term. According to the author, a plausible explanation for this result is the Baumol's (1967) model of unbalanced growth that predicts a tendency for per capita output in mature economies to stagnate (Hartwig, 2008:4)[40]. Nevertheless, Nolte and McKee (2008) – as already referred – found an important role of the healthcare systems in explaining the decline of avoidable mortality in industrialized countries.

Soukiazis and Cravo (2008) implemented a dynamic panel data approach for 77 countries over the period 1980-2000 and they divide this sample in three subgroups according to their per capita income level. The authors show that for the whole sample both health (measured by infant mortality rate) and human capital (measured by article publication rate) as well as physical capital are important determinants of economic growth and convergence. The authors also analyze the convergence process in the different subgroups and they found that while in the high-income countries human capital is more relevant, in the low-income countries health is more important to differentiate these economies.

Using proxies for the incidence of mortality caused by chronic diseases, Suhrcke and Urban (2006) compare 26 rich countries for the period 1960-2000, using cardiovascular disease mortality (CVD) rate as a proxy for health. Implementing a dynamic panel growth approach, the authors found that CVD mortality rate in working-age population is a robust predictor of subsequent five-year growth rates. Their empirical analysis shows that a reduction of CVD mortality by 10% was associated with an increase in the growth of per capita income by 1%. Last but not the least, Swift (2010) also analyzed the effects of cancer on GDP growth in Australia over the period 1907 – 2006 using Johansen multivariate cointegration. The author's empirical results show that an increase of 1% in cancer mortality rates will result in 1.6% decrease in GDP per capita, while 1% increase in the dependency ratio corresponds to a 0.9% decrease in GDP per capita.

[40] According to Baumol's (1967) model, this tendency for per capita income in a mature economy to stagnate is due to differences in the productivity levels between a 'progressive' (manufacturing) sector and a 'nonprogressive' (services) sector and to an increasing shift of the expenditure share for the 'nonprogressive' sector (for instance, expenditure with health care services).

3.4 Model, data and methodology description

Our empirical approach follows the MRW (1992) model, which as explained in Chapter 2, improves the Solow model by including the accumulation of both human and physical capital. In our model human capital is intended in a broader sense that includes education as well as health conditions.

The growth equation to estimate is given by:

$$gy_{i,t} = b\ln\left(y_{i,t-1}\right) + c_1\ln\left(n_{i,t} + g + \delta\right) + c_2\ln\left(k_{i,t}\right) + c_3\ln\left(E_{i,t}\right) + c_4\ln\left(H_{i,t}\right) + \varepsilon_{i,t} \qquad (3.1)$$

where $\varepsilon_{i,t} = \alpha_i + u_{i,t}$, with α_i denoting the country-specific effects or measurement errors and $u_{i,t}$ refers to the idiosyncratic error term.

The dependent variable, $gy_{i,t}$, is the growth of per capita income considering five year intervals. We regress $gy_{i,t}$ on $y_{i,t-1}$, the initial per capita income of each period whose coefficient reflects the well-known convergence hypothesis[41] when appears with negative sign; $n_{i,t}+g+\delta$ is the annual growth rate of population plus the rate of technological progress (g) and the rate of capital depreciation (δ); $K_{i,t}$ denotes the investment share, $E_{i,t}$ is human capital (proxied by the number of patents per million of inhabitants aged 25 or over[42]) and $H_{i,t}$ represents the health capital[43].

We estimate this equation using panel data for 22 OECD countries (given by the subscript i) over the period 1980-2004. With the aim of controlling economic cycle effects, we consider five year intervals, so each country has six observations (given by

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[41] Barro and Sala-i- Martin (1992) developed this idea.

[42] Empirical evidence from recent studies (Soukiazis and Cravo, 2008; Antunes and Soukiazis, 2008) show that in the OECD sample the "average years of schooling" is not the most suitable proxy for human capital, and that other proxies must be used to capture the efficiency of human capital, such as, scientific production (proxied by the rate of published articles) or activities related to R&D (proxied by the rate of registered patents). Therefore, to differentiate better the OECD countries with respect to human capital we considered the "number of patents per million of inhabitants aged 25 or over". Nevertheless, as alternative, we also estimated the model using the "average years of schooling" but since empirical results were not robust we opted not to report here.

[43] In the Annex 3.A (Table 3.3) we explain the set of variables considered in our empirical study and the data sources.

the subscript *t*). Having in mind our aim – to capture the impact of different dimensions of health on economic growth – we opt to consider several health proxies (one at a time to avoid possible colinearity) that we consider pertinent to characterize the health systems of the OECD countries.

In our empirical analysis we use several health proxies aiming to capture three different dimensions of health in the OECD countries: (*i*) the health status of the population, using life expectancy at birth (*lifexpect*), life expectancy at 65 years old for female and males (*lifexpect65f* and *lifexpect65m*, respectively), infant mortality rate (*IMR*) and mortality rates caused by chronic diseases like avc and cancer (*AVC* and *cancer*, respectively); (*ii*) the health care service, measured by the average length of stay (*stay*) and (*iii*) the health care resources measured by the availability of practice physicians[44] and acute care beds[45] (*physicians* and *acbeds*, respectively)[46].

In what concerns the role of each explanatory factor, we expect that *lifexpect*, *lifexpect65f* and *lifexpect65m* will have a positive impact on economic growth, since an increase in these proxies means health improvements. On the contrary *IMR, AVC* and *cancer* are mortality rates and so they represent a human loss and, consequently, should have a negative impact on economic growth. In what respects *stay*, a decrease of the length of *stay* is indeed a tendency in developed countries which is associated with increasing efficiency of health care services. Therefore, we expect a negative association between stay and economic growth. The number of acute care beds (*acbeds*) is directly linked with *stay* and also shows a tendency to decrease in rich countries, so we expect a negative impact too. At last, we expect that *physicians* will have a positive contribute to economic growth since an increase of practising physicians is related to easier access to health care services.

[44] Practising physicians are those seeing patients either in a hospital or elsewhere (OECD, 2008).

[45] Acute care beds are defined as beds accommodating patients in a hospital or hospital department whose average length of stay is 30 days or less until the 1980s and 18 days or less afterwards (OECD, 2008).

[46] We also considered initially the share of public health expenditure on GDP as a proxy for the financial resources devoted to health sector. The estimated coefficient was negative – in line with results found by Hartwig (2008) – although without statistical significance. However, since the Hansen test rejected the null hypothesis (absence of autocorrelation between instruments and errors (Arellano and Bond, 1991)) at 5% significance level, we opted not to report here.

Table 3.1 – Descriptive statistics of the variables (22 OECD countries[47], 1980-2004)

Variable	Observations	Mean	Std. Deviation	Coef. Variation	Min	Max
y	132	21233.22	5286.95	0.25	9956.77	36100.44
n	132	0.05	0.00	0.07	0.05	0.07
k	132	23.15	3.59	0.16	13.66	34.41
pat	132	178.55	180.05	1.01	0.95	988.50
lifexpect	132	76.93	2.18	0.03	71.50	82.10
lifexpect65f	132	18.92	1.42	0.08	15.70	23.30
lifexpect65m	132	15.24	1.41	0.09	12.50	18.20
IMR	131	7.16	3.34	0.47	2.80	24.20
AVC	130	70.78	38.95	0.55	29.20	273.90
cancer	130	177.60	20.77	0.12	136.20	222.50
stay	114	8.64	4.11	0.48	3.40	33.20
physicians	117	2.66	0.72	0.27	1.30	4.90
acbed	109	4.53	1.67	0.37	2.20	12.00

Table 3.1 reports some elementary descriptive statistics for the variables considered in our study in order to have an initial idea on its dimensions. As we can see most of the health proxies used assume a higher value of the coefficient of variation, namely *AVC*, *stay*, *IMR* and *acbed*, and so we expect them to have an important impact in the estimation approach. We can also confirm that the proxy used for the human capital qualifications – *patents* – shows the highest relative dispersion and so we expect this variable to be an adequate proxy for differentiating human capital and innovation activities among the OECD countries.

Methodology

When we add health conditions to the economic growth models, we must take into account some additional difficulties in specifying the empirical model. One of the problems is related to unobservable heterogeneity. Countries have different economic, political and institutional characteristics and so the use of linear regressions that do not take into account these differences are not adequate. As Islam (1995) notes, panel data

[47] The 22 OECD countries considered in our sample (for which data was available) are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States of America.

techniques are more suitable, since they take into account different structures across countries, in the form of fixed or random effects.

Another problem has to do with measurement error. When there are several badly measured variables or when they depart from classical hypotheses, the bias can be in either direction (Temple, 1999). This is in fact a critical issue when testing the effect of health on economic growth because of the problem of restrictions on the availability of data (as already discussed in Chapter 2) but also because of the endogeneity of regressors. Given this endogeneity problem, the use of Ordinary Least Squares (OLS) delivers biased and inconsistent estimates.

To avoid the endogeneity problem of the regressors, instrumental variables techniques are often used (Bloom *et al.* 2001; Rivera and Currais, 2005). An instrumental variable must satisfy two conditions: first, it should be correlated with the endogenous explanatory variable and, second, it should not be correlated with the error term. Usually lags of the endogenous variables are considered as instruments. Yet, as Temple (1999: 129) notes, in what concerns human capital accumulation there may be some delay in the effects of this factor and the exogeneity of the instruments is not always clear. Another problem to consider is the omitted variable bias due to omission of relevant factors that explain growth.

Having in mind these problems, and in order to obtain consistent and efficient estimates, we use the Generalized Method of Moments (GMM) panel estimation technique designed by Arellano and Bond (1991)[48]. According to Arellano (2003), some of the reasons that make the use of GMM techniques in dynamic panel data popular are that the estimates are consistent in short panels, are robust and have general applicability. On the other hand, GMM methods allow controlling for measurement errors and omitted variables bias. According to Bond *et al*. (2001), the use of difference-GMM techniques in studying economic growth has important advantages over cross-section regressions or other estimation methods for dynamic panel data models. In fact, it avoids the problem of omitted variables that are constant over time (unobserved country-specific effects) and so estimates will no longer be biased. On the other hand, the use of instrumental variables allows parameters to be estimated consistently in models that include endogenous right-hand-side variables even in the presence of measurement error. However, it must be noted that difference GMM has also some

[48] This approach was first introduced in the growth literature by Caselli *et al*. (1996).

disadvantages. When the time series are persistent and the number of time series observations is small, the first difference GMM is poorly behaved because lagged levels of variables are weak instruments for subsequent first-differences.

There are two kinds of estimators obtained from one-step and two-step estimations. They differ in the errors assumptions. One-step considers the errors to be i.i.d., while two-step estimator assumes the heteroscedasticity of errors. According to Windmeijer (2005), two step GMM estimates are better than one step, because it has lower bias and smaller standard errors and this was the methodology we used. Because the two-step estimates of the standard errors tend to be downward biased (Arellano and Bond, 1991), the standard errors are corrected via a finite-sample correction to the two step covariance matrix derived by Windmeijer (2005)[49].

We used lagged variables as instruments. The choice of the number of the instruments must have in consideration that there is a trade-off between increased efficiency of additional instruments and an aggravation of the weak-instrument problem, if additional time lagged instrumental variables are only weakly correlated with the instrumented covariate (Suhrcke and Urban, 2006). As Roodman (2006) points out, the use of too many instruments, although does not compromise the coefficient estimates, can weaken the Sargan/Hansen test, so the number of instruments should be reported and check the robustness of the results. In order to reduce the number of instruments we used the collapse command[50].

The Hansen statistic of over-identifying restrictions tests the validity of the instruments for the GMM models, assuming in the null hypothesis that the instruments are not correlated with the residuals. The tests of Arellano-Bond (AR) indicate whether there are problems with serial correlation of the error terms. Test for AR(2) in first differences assumes in the null hypothesis that the errors in the first difference regression exhibit no second order serial correlation.

As Table 3.1 shows, some of the proxies of health considered in our model have missing observations, so in those cases we have an unbalanced panel. In order to get consistent estimates of the parameters of interest, and following Roodman (2006), we used two common transformations: the first-difference and the orthogonal deviations

[49] The command xtabond2 designed by Roodman and available in STATA version 9.2 performs difference GMM (both one-step and two-step) and computes automatically this correction.

[50] This is available from the STATA command xtabond2 (Roodman, 2006).

transformation. The first-difference transformation eliminates the country-specific effects, but has the disadvantage of increasing gaps in unbalanced panels. In those cases, we used "forward orthogonal deviations" or "orthogonal deviations" transformation which subtracts the average of all subsequent available observations of a variable. This procedure is computable for all observations except the last for each country and so it minimizes the data loss[51]. On the other hand, both transformations allow the use of lagged variables as valid instruments and so they are consistent and comparable.

[51] We ran this transformation using the command "orthog" available on STATA version 9.2.

3.5 Empirical evidence

Since our main aim is to analyze the impact of health conditions on economic growth, we will give a special attention to the results related to health proxies we used.

Table 3.2 reports the results from the dynamic panel estimation using difference-GMM. In the growth regressions of the Solow's type with physical capital and population growth, we assume that physical capital depreciation plus technical progress is 0.05 as in MRW. In columns (1) to (8) we analyze the effects of introducing different proxies for health, one at a time, to avoid possible colinearity between the regressors.

As Table 3.2 shows, in all the regressions the initial per capita income has a negative impact on economic growth, as expected, confirming therefore the hypothesis of conditional convergence. The annual growth rate of population has a positive sign, with the exception of models (3) and (7), but always with no statistical significance. As expected, physical capital has a positive and significant impact, with the exception of models (3) and (7) where the estimated coefficient loses significance. In what respects the variable *patents*, with the exceptions of models (1) and (2), it has a positive impact (as expected) on economic growth. However, it only shows a positive and statistical significant impact (at the 10% level) in model (8).

One important aspect to notice is that introducing human capital and health conditions in the growth model the convergence coefficient in most cases gains statistical significance, showing that human capital and health are important factors for explaining growth and convergence. On the other hand, all the health proxies used are shown to be statistically relevant.

Table 3.2 – The Relevance of Health Factors on Growth. GMM Panel Regressions, OECD Countries, 1980-2004

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ln($y_{i,t-1}$)	-0.1781*	-0.1827**	-0.1211***	-0.1742***	-0.0872***	-0.1543**	-0.1469***	-0.1922***
	(-2.065)	(-2.433)	(-3.264)	(-4.244)	(-2.937)	(-2.172)	(-7.705)	(-6.105)
ln($n_{i,t}+g+\delta$)	0.0647	0.0955	-0.0583	0.1207	0.1068	0.0135	-0.0622	0.1085
	(0.964)	(0.893)	(-0.482)	(1.148)	(1.120)	(0.107)	(-1.159)	(0.922)
ln($k_{i,t}$)	0.0718*	0.0981***	0.0273	0.0640***	0.0825**	0.0694*	0.0349	0.0805***
	(1.788)	(3.337)	(0.597)	(2.976)	(2.432)	(1.950)	(1.394)	(2.857)
ln($pat_{i,t}$)	-0.0096	-0.0040	0.0019	0.0030	0.0107	0.0087	0.0019	0.0408*
	(-0.483)	(-0.190)	(0.0910)	(0.255)	(0.678)	(0.495)	(0.232)	(2.072)
ln($lifexpect_{i,t}$)	1.1653*							
	(1.822)							
ln($lifexpect65f_{i,t}$)		0.4293**						
		(2.237)						
ln($lifexpect65m_{i,t}$)		0.0448						
		(0.246)						
ln($IMR_{i,t}$)			-0.0553**					
			(-2.473)					
ln($AVC_{i,t}$)				-0.0924***				
				(-2.906)				
ln($cancer_{i,t}$)					-0.1177**			
					(-2.298)			
ln($stay_{i,t}$)						-0.0919***		
						(-3.490)		
ln($physicians_{i,t}$)							0.1417***	
							(6.142)	
ln($acbed_{i,t}$)								-0.0899***
								(-2.882)
Observations	88	88	86	86	86	77	79	74
Nr of countries	22	22	22	22	22	21	22	21
Nr of instruments	10	12	10	10	10	10	10	10
AR2	0.874	-0.492	1.641	0.0302	0.653	0.800	0.341	-0.239
AR2 p-value	0.382	0.623	0.101	0.976	0.514	0.424	0.733	0.811
Hansen test	6.263	7.179	8.262	6.588	9.072	5.250	3.139	3.279
Hansen p-value	0.281	0.305	0.142	0.253	0.106	0.386	0.679	0.657

Notes:

The dependent variable is the annual average growth rate of per capita income considering five year intervals with the exception of the last regression which considers four year intervals; ln(yi,t) is the initial per capita income of each period; ln(ni,t) is the annual average growth rate of population considering five year intervals; the values of all other variables refer to the initial year of each period.

Regressions (8) and (11) do not include New Zeland and regression (9) doesn't include Ireland due to lack of data.

AR2 test for second order autocorrelation. Hansen J-test tests for overidentifying restrictions.

t statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1

As Table 3.2 shows, at the 1% statistical significance level, the variables *AVC* (cerebrovascular diseases mortality rate), column 4; *stay* (average length of stay for acute care), column 6, and *acbeds* (number of acute care beds), column 8, have a negative impact on economic growth, as expected.

Another significant result from the estimation approach is that the variable *physicians* (column 7) has a positive impact on growth at the 1% significance level.

These results confirm the relevance of the health proxies used in the growth equation. In fact, mortality rates caused by *avc* are a severe problem (being a priority issue on the agenda of WHO and other institutions), mainly in most developed countries, responsible for a high loss of human resources potentiality. It is important to note that this kind of disease doesn't kill just the elderly but it affects also an increasing number of people still at working age. Interpreting our results, we can predict that a 1% increase in the mortality rate caused by cerebrovascular diseases is responsible for 0.0924% decrease in the growth of income per capita, all other things being constant.

In what concerns the variable that measures the average length of stay for acute care (*acbeds*) its negative impact on per capita income may be interpreted as revealing a kind of resource efficiency associated to the progress made in the health sector. Our model predicts (from column 8) that a 1% reduction in the average length of stay is responsible for 0.0919% increase in per capita income growth, all other things being constant. According to OECD (2007), most of the countries of this group registered an important decline in this indicator (average length of stay for acute care has fallen from 8.7 days in 1990 to 6.3 days in 2005 - for the 25 countries for which consistent data over time was available), which can be explained by the advances made on day surgery that avoids long stay in hospitals and to the expansion of early discharge programs that allows patients to go home earlier and to receive follow-up care. On the other hand, it is also plausible to think that this impact is attributable to the cost reduction policy made possible by a reduction in the length of stay in hospitals.

This downward trend in "*stay*" is directly associated with the evolution of the number of acute care beds ("*acbed*"). In fact, according to OECD (2007), most of the countries of this group show a long-term trend towards a decline in the number of acute care beds: considering a group of 24 countries, the average number of acute care hospital beds dropped from 5.1 per 1000 population in 1990 to 3.9 in 2005. Once more this was possible, at least partly, by the progress made in medical technology. At the same time, health reforms in OECD countries have been characterized by cost-reducing strategies in the medical sector. At the 1% statistical significance level, our results show (column 11) that a decrease in "*acbed*" has a positive impact on economic growth: it is predicted that 1% decrease in the number of acute care beds is responsible for 0.0899% increase in income per capita growth, all other things being constant.

The variable "*physicians*" has a significant positive impact on the standards of living, as expected. It is predicted that 1% increase in the number of practicing physicians causes a 0.1417% increase in income per capita growth, all other things being constant. This is also an encouraging result showing the contribution of labour force employed in the health sector for improving the standards of living of the whole population.

At the 5% significance level, *IMR* (column 3) has the predicted negative effect on income growth showing that, if *IMR* increases 1% income growth decreases 0.06%, all other things being constant. It should be noted that, although usually it is not given too much attention to differential gains in what concerns infant mortality rate of developed countries, there are still some important differences: according to OECD (2008a) in 2004 the lowest infant mortality rates were reported in Nordic countries and Japan but in USA the same rate was relatively high (more than 6 deaths per 1 000 live births against 2.8 and 2.3 in Japan and Iceland, respectively). These differences can be explained in part by the increasing number of premature births (leading to a rising number of babies born with low weight) which is linked to the delay of motherhood decision and to the rise in multiple births by fertility treatments. According to OECD (2008a), there is a higher risk of neonatal deaths that has contributed to higher infant mortality rates in some developed countries (like USA) and that can lead to an inversion of the downward trend in infant mortality rates that characterized the OECD countries over the past few years.

As expected, deaths caused by cancer have an important negative impact on economic growth in the OECD countries, being one of the most important causes of death. Like *AVC*, this proxy reflects the burden of chronic diseases in the OECD countries and shows statistical significance at the 5% level with elasticity equal to -0.12% (column 5). While being in fact one of the main causes of death, it is also, in a great part, avoidable. So, it is of extreme importance the investment in education to enhance health literacy, the implementation of prevention strategies and the early detection of health problems. At the same time, investment in laboratory research, in technology progress and in treatment and care play a crucial role in controlling this disease.

In what respects life expectancy at 65 years old according to gender, this proxy has statistical significance only for females, showing a positive impact on growth as expected. A possible explanation for this result is that the number of years of life expectancy gained (especially at 65 years old) is higher for women than for men and that there are still disparities in the health status according to gender.

At the 10% significance level, life expectancy at birth has a positive effect on income with elasticity equal to 1.17% (column 1). This is an expected result since higher life expectancy (meaning an improvement of the health status of the population) is an incentive for people to invest more in education and health care and save more for retirement plans.

3.6 Chapter concluding remarks

The aim of this chapter was to analyze the impact of health conditions on economic growth, using a growth regression framework. Given the relatively scarce literature that concerns specifically developed countries, we focused our attention on 22 OECD countries in order to a better understand of the role of health factors on economic growth and convergence.

Having in mind some mixed results already obtained by other authors, depending on the sample and methodologies used, in this chapter we analyzed the impact of health proxies that may characterize more properly OECD countries. Along with infant mortality rate or life expectancy (the most traditional used health proxies) we also considered mortality rates caused by chronic diseases or variables that measure resources and the activity of health care systems. These proxies can differentiate more properly health conditions of the developed countries and so they can be more relevant in measuring their impact on economic growth and convergence.

On the other hand, additional problems have to be taken into account when health factors are considered, mainly because of the endogeneity of the regressors. Following recent developments in the economic growth literature, the methodology we used was based on panel data dynamic analysis and estimations were made for the period 1980-2004 using GMM methods. This methodology is more adequate to deal with the endogeneity of the regressors.

Our empirical analysis shows that health conditions are important conditioning factors to growth and convergence. Our findings suggest that the proxies we used for chronic diseases, health care activity and resources devoted to health care are pertinent in explaining economic growth and convergence between this group of countries. In fact, our empirical evidence shows that cerebrovascular mortality rates, average length of stay, number of physicians and acute care beds are the most significant health factors affecting the standards of living of these developed countries. These results reinforce the idea that to analyze the impact of health on economic growth we need to go beyond the use of the most conventional factors. Other health conditions, such as infant mortality or life expectancy, have their expected impact on income, but at a lower level of statistical significance.

Our results suggest some policy implications. Investment in preventing and controlling chronic diseases seems to be of extreme importance. For instance, it is important the implementation of educational policies that may influence lifestyles and contribute to more conscious risk behaviour. On the other hand, given the cost reduction strategies that characterize rich countries’ health systems and, at the same time, the need to allocate more resources to control this kind of diseases, it is necessary to evaluate the efficiency of resource allocation in the health sector.

Annex 3.A.

Table 3.3 – Description of variables and data sources

Variable	Description	Source
y	Real GDP per capita (Laspeyres), dollars in 2000 constant price – RGDPL	Penn World Table 6.2.
n	Annual average growth rate of population	Penn World Table 6.2.
k	Investment share as a percentage of RGDPL in 2000 constant prices	Penn World Table 6.2.
pat	Number of patents per million of inhabitants aged 25 or over	USPTO (patents) and International Labour Office (population)
lifexpect	Life expectancy at birth, in years	OECD, Health Data 2008
lifexpect65f	Life expectancy at 65 years old (females), in years	OECD, Health Data 2008
lifexpect65m	Life expectancy at 65 years old (males), in years	OECD, Health Data 2008
IMR	Infant mortality rate	OECD, Health Data 2008
AVC	Cerebrovascular diseases: deaths per 100 000 total population	OECD, Health Data 2008
cancer	Cancer: deaths per 100 000 total population	OECD, Health Data 2008
stay	Average length of stay for acute care, all conditions (days)	OECD, Health Data 2008
physicians	Practising physicians, density per 1 000 population	OECD, Health Data 2008
acbed	Acute care beds, density per 1 000 population	OECD, Health Data 2008

Notes:

Penn World Table Version 6.2 available at Heston *et al*. (2006), http://pwt.econ.upenn.edu/php_site/pwt_index.php. Accessed 15 July 2008.

Data for U.S. Patent and Trademark Office (USPTO) is available at http://www.uspto.gov. Accessed 17 July 2008.

Data for International Labour Office is available at http://laborstat.ilo.org. Accessed 28 July 2008.

OECD Health Data 2008 is available at http://www.oecd.org/topicstatsportal. Accessed 17 July 2008.

Chapter 4

Health Status Determinants in the OECD Countries. A Panel Data Approach with Endogenous Regressors*

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4.1 Introduction

As it has been shown in the previous chapter, health, along with education, is important not only for individuals' wellbeing but also for economic performance. One important outcome of increasing standards of living is the raise of life expectancy at birth by 10.6 additional years (on average) in the OECD countries since the sixties[52]. As our empirical results of the previous chapter show, life expectancy is statistical significant in explaining the economic growth and convergence among these countries and so we consider pertinent to analyze its main determinants.

Contrasting with less developed countries, where increased longevity is explained chiefly by a reduction in infant mortality rate, in developed countries the raise in life expectancy is mainly due to reductions in the mortality rates of the middle-aged and the elderly. However, as people tend to live longer, there are new challenges to deal with. Additional gains on life expectancy will be harder to achieve and the effort will be concentrated in offering better quality of life through new treatments and better health care. It is important to mention that as people get older and live more years it is more likely the prevalence of certain diseases – phenomenon known as the effect of general biological deterioration[53] - that imply the need for medical treatments and an increase on health care spending. In this context, it is consensual the need to invest more in primary prevention to reduce the rising incidence of diseases and to contribute to a healthier aging population. Therefore, education, directly linked with health literacy[54], must be seen as one driving force of health spending efficiency. As Phelan and Link (2003)

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[52] According to OECD (2009), average life expectancy of OECD countries was 68.5 years in 1960 and 79.1 years in 2007.

[53] As Kiuila and Mieszkowski (2007) argue, the general biological deterioration is reflected by the significant increase of the incidence of various diseases after the age of 65 and by the general deterioration of physical robustness during old age, which reduces the impact of socioeconomic factors on health status and mortality.

[54] According to the WHO (1998), health literacy can be defined as "[t]he cognitive and social skills that determine the motivation and ability of individuals to gain access to, understand, and use information in ways that promote and maintain good health. Health literacy means more than being able to read pamphlets and successfully make appointments. By improving people's access to health information and their capacity to use it effectively, health literacy is critical to empowerment."

note, policymakers should look at the effects of education on poverty (or other social factors that affect health) as a means to improve health status.

In this perspective, it is very important to know and quantify, in a macroeconomic perspective, which are the main health determinants and to know the magnitude of their potential impacts.

Having this in mind, in this chapter our aim is to analyze the main determinants of the health status of the OECD population expressed by their longevity (proxied by life expectancy at different ages). To do so, we use a panel data approach to estimate the health status equations controlling for the endogeneity of some of the determinants of health, an issue often neglected in this kind of literature. Since there are still persistent differences between genders well reflected in life expectancy at 65 years old (higher for women than for men[55]), with this analysis we also aim to highlight the different role and different impact of socio-economic factors, health resources and lifestyles at various ages or gender. With this approach we intend to disentangle and to better explain the effects (and magnitude) of income, education and lifestyles on life expectancy at birth (for total population, for males and females) and at 65 years old (for males and females[56]).

This chapter is organized as follows. Section 4.2 explains the determinants of health status and section 4.3 reviews some of the existing literature. In section 4.4 we explain the model, the data and the methodology used in the empirical analysis. The results obtained from the estimation approach are presented and discussed in section 4.5. The last section summarizes the main findings suggesting some policy implications.

[55] According to OECD (2009), life expectancy for females at age 65 is, on average, over 20 years, while for males it is almost 17 years.

[56] There is no data available for life expectancy at 65 years old for the total population.

4.2 The determinants of health status

Most studies that concentrate their analysis on the determinants of the health outcomes at an aggregate level generally emphasize the role of socio-economic factors (which include per capita income and education, for instance), the availability of health care resources and the impact of lifestyles. As we have already discussed, health is directly linked to education and income and these are in fact three very important dimensions of wellbeing. In the economic literature there is consensus on the existence of a positive association between them. However, the direction of causality is not very clear, because of the existence of reverse effects or other factors that can influence simultaneously education, health and income.

Since in this study our aim is to estimate a health production function, we are interested in analyzing the impact of education and income (along with other factors that represent lifestyles) on health improvement. On the other hand, we want to highlight the causality effects among health, education and income.

There are well established conceptual links between education and health[57]. Increased education, as human capital theories predict, makes individuals more productive. Higher education in developed countries is associated with better jobs and better wages[58] which allow for better health care and provision. Skilled individuals usually have safer jobs (as they do more intellectual than physical work) and better work conditions. On the other hand, more educated people are more informed and aware of the risks of adopting less healthy lifestyles. Several studies also show empirical evidence of a direct link between the education level of mothers and the health status of their children (Buor, 2003; McCrary and Royer, 2011).

[57] In a microeconomic perspective, a seminal work was due to Grossman (1972) that showed that individuals with more education have a higher preference for health capital levels. In a macroeconomic perspective the existing relationship between education and health was shown by several authors (Albert and Davia, 2007; Cutler and Lleras-Muney, 2006; 2010, among others).

[58] In the latest OECD *Education at a Glance 2009* report (OECD, 2009b), data show that earnings for those with tertiary education relative to upper secondary education provide a good measure of the supply and demand for individuals with higher education, as well as the incentives to invest in higher education. Some countries have experienced a significant increase in the earnings premium for tertiary educated individuals over the period 1997-2007. Another important conclusion is that earnings increase with each level of education and that the earnings premium for tertiary education is substantial in most countries, exceeding 50% in 17 out of 28 countries.

Individuals with higher levels of education also have a more efficient use of health care resources. The adoption of a health-seeking behaviour is associated with health literacy. At the same time, societies with higher levels of tertiary education also invest more in R&D, including the health sector. As Ricci and Zachariadis (2009) note, a country's absorptive capacity for health-related technology and ideas is improved by a higher average level of education in the economy. According to these authors it is also expectable that physicians will adopt and implement new treatments to the general population where the average patient is more educated, since he/she is more receptive to new medical knowledge.

It is pertinent to assume that the relation between health and education is bidirectional. As it is widely accepted a raise in life expectancy makes investment in education more likely, because individuals expect to have the return of this investment for a longer period of time. Therefore, education must be assumed endogenous when a health equation is estimated. More educated people are healthier for reasons we explained above, but healthier people are also able to accumulate more knowledge over the life cycle.

Another important determinant of longevity is income. Higher income is also associated with better health. It allows individuals to have a better quality of life, which can be related to a healthier nutrition and greater access to health care products and services with positive consequences on health. It is also important to note that the relation between health and income is reciprocal with feedback effects and cumulative characteristics; higher income implies better health, and healthier people are normally wealthier since they are able to have better jobs and better payment (Adams *et al.*, 2003). Therefore, the income variable has to be considered as endogenous in the health equation.

As Kiuila and Mieszkowski (2007) note, it is expectable that, as people get older these socio-economic factors tend to have less importance in explaining mortality rates. As they point out, there is a selection process at younger ages which results in the narrowing of the mortality differentials of different socioeconomic groups after the age of 65. At these ages there are other factors, such as the availability health care resources and lifestyles that can play an important role determining the health status of the population. In what concerns lifestyles, it is well known the negative impact certain behaviours have on health: most chronic diseases, like obesity, diabetes or cerebrovascular diseases, also depend on behaviour choices[59]. Although there are also important genetic/biological factors explaining the incidence of diseases, there is consensus on the critical role of behavioural risks on health. According to WHO (2009), the most important (and modifiable) risk factors are unhealthy diet and excessive energy intake, as well as physical inactivity and tobacco use[60].

[59] According to Lee *et al*. (2007), 50% of premature deaths are related to risky health behaviours, and 70% of disease burdens and costs are due to risky behaviours.

[60] Besides psychosocial and genetic factors, the WHO (2008) considers that other risk factors for chronic disease include infectious agents, responsible for cervical and liver cancers, environmental factors (such as air pollution), which cause asthma and other chronic respiratory diseases.

4.3 Literature review

Most empirical studies that examine the determinants of health status at a macroeconomic level usually follow either the production function approach or the data envelopment analysis (DEA)[61]. The health production function approach considers healthcare resources, socio-economic and lifestyles factors as the main determinants of health status, while DEA is a nonparametric method of estimation that considers a convex production frontier and allows for the calculation of technical efficiency measures.

Using the first method Or *et al*. (2005) showed that for 21 OECD countries, for the 1970-1998 period and using panel data regressions, the impact of health care measured by the number of doctors on life expectancy at birth and at age 65 varies significantly across countries. They found that the availability of advanced medical technology plays an important role too. Shaw *et al*. (2005), following also the health production function for developed countries, found that pharmaceutical expenditures have a positive effect on life expectancy at middle and advanced ages. According to these authors, another important determinant of life expectancy is lifestyle: they show empirical evidence that a decrease in tobacco consumption by about two cigarettes per day or an increase in fruit and vegetable consumption by 30% raises life expectancy approximately one year for 40-year-old females. On the other hand, Nixon and Ulman (2006) using fixed effects panel regressions for the early 15 members of the European Union over the period 1980-1995, found that increases in health care expenditure are significantly associated with large improvements in infant mortality but only marginally in relation to life expectancy.

Some other recent studies are due to Ramesh and Mirmirani (2007), Ricci and Zachariadis (2009) and Joumard *et al.* (2008). Ramesh and Mirmirani (2007) analyzed the health care system of 25 OECD countries, using a fixed-effects panel data model for the 1990-2002 period. They estimated two regressions, one for life expectancy and another for infant mortality. Their empirical results suggest that supply of physicians and education levels are highly significant and conditional factors for both the life

[61] The health production function approach assumes health as an output that is produced by several inputs (see, for instance, Thornton (2002)). Alternatively, DEA is a nonparametric method of estimation of the best practice frontier. See, for instance, Afonso and Aubyn (2006).

expectancy and infant mortality. Ricci and Zachariadis (2009) in a cross sectional analysis of 71 countries found empirical evidence that higher education is a significant determinant of longevity and that it is more robust than female literacy, sanitation, spending on medicine and per capita income. Finally, Jourmand *et al.* (2008) used the two different approaches - panel data regressions and DEA analysis – to estimate countries' relative performance in transforming health care resources into longevity. Their empirical estimates suggest that potential efficiency gains might be large enough to raise life expectancy at birth by almost three years on average for the OECD countries, while a 10% increase in total health spending would increase life expectancy by three to four months.

Some empirical studies that followed DEA approach include Puig-Junoy (1998), Afonso and Aubyn (2006) or Verhoeven *et al*. (2007). Puig-Junoy (1998) studied the OECD countries for the 1960-1990 period adopting life expectancy at birth as health output and the number of physicians, non-physician health care employees and number of hospital beds as inputs. They found empirical evidence that, for similar health outputs, non-efficient countries use on average 40% more inputs than efficient ones. Afonso and Aubyn (2006) estimated a semi-parametric model of the health production function using a two-stage DEA approach for OECD countries. They showed that life expectancy is strongly related to GDP per capita, education level and health behaviour (obesity and smoking habits). Verhoeven *et al*. (2007), in an attempt to assess the efficiency of education and health spending in G7 countries, for the period 1998-2003, used in their analysis, an index of 28 OECD countries' average ranks for number of hospital beds, physicians and health workers *per capita*, immunizations and doctors' consultations. One of the findings of this study was that more immunizations and doctors' consultations were associated with higher efficiency in the health sector.

4.4 Model, data and methodology description

An important technical issue in the health empirical literature is the endogeneity problem of some of the determinants of health status that has not been considered in great deal. The existence of this problem can affect the estimated results providing biased and inconsistent estimates. In our analysis the health equation we estimate and the estimation technique used take into account the endogeneity of the regressors providing more reliable results.

Therefore, in this chapter we adopt a panel data framework, using data from the OECD Health Data 2009. According to the health production function approach[62], the equation to estimate is defined as follows:

$$\ln LE_{i,t} = b\ln\left(Incomepc_{i,t}\right) + c_1 \ln\left(Education_{i,t}\right) + c_2 \ln\left(Health\,\mathrm{Re}\,s_{i,t}\right) + c_3 \ln\left(Tobacco_{i,t}\right) + \\ + c_4 \ln\left(Alcohol_{i,t}\right) + \varepsilon_{i,t} \tag{4.1}$$

where, $\varepsilon_{i,t} = \alpha_i + u_{i,t}$ with α_i denoting the country-specific effects or measurement errors and $u_{i,t}$ refers to the idiosyncratic error term.

We estimate five equations[63]. The dependent variable, $LE_{i,t}$, represents the health status proxy considering first, life expectancy at birth for total population, for males and females, and alternatively, life expectancy at 65 years old for males and females. The determinants of health status are: the per capita income of each period, $Incomepc_{i,t}$; the average years of education of the population aged 25-64, $Education_{i,t}$; a proxy for the resources devoted to health care represented by per capita consultations[64], $HealthRes_{i,t}$; and two variables reflecting lifestyles, namely, tobacco smokers (% of population of age

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[62] See, for instance, Joumard *et al.* (2008) for a similar production function specification.

[63] The regressions were run on Stata 9.2., using xtivreg2, which implements IV/GMM estimation of panel data models with possibly endogenous regressors.

[64] OECD (2009) defines doctors' consultations as the number of contacts with an ambulatory care physician divided by the population. It includes visits/ consultations of patients at the physician’s office; physician’s visits made to a person in institutional settings or discharge planning visits, made in a hospital or nursing home with the intent of planning for the future delivery of service at home; visits made to the patient’s home. It excludes telephone contacts.

15 and over who are daily smokers), $Tobacco_{i,t}$, and alcohol consumption (litters per capita of population aged 15 and over)[65], $Alcohol_{i,t}$, respectively[66].

Based on the links that characterize the relation between health, income and education already explained in section 4.2, we expect that both per capita income and education are positively related with life expectancy. In what concerns health resources proxied in our model by per capita consultations, we can expect that the use of health care services will be reflected in a better health status (the higher the consultations the better health care is provided to populations). In fact, the choice of per capita consultations as a proxy for health care resources is explained mainly by two reasons: it is a measure of an effective use of the available resources (human and physical); on the other hand, it is a different proxy from those conventionally used in the health literature (such as the number of doctors or the number of hospital beds). In a certain way it may also capture the efficiency of the health system, as Verhoeven *et al*. (2007) found out that doctors' consultations were related with higher efficiency in the health sector of rich countries.

Finally, we expect a negative impact of lifestyles on life expectancy, as they represent well known harmful habits for health. Smoking has been identified as the major cause of preventable death in the OECD countries (OECD, 2009a). Health problems related to smoking depend on the duration (years of smoking) and the intensity of use (number of cigarettes smoked). The main causes of death associated with smoking are cardiovascular diseases, chronic pulmonary diseases and lung cancer. Additionally, it is also associated with sudden infant death syndrome and respiratory problems in children (WHO, 2008). In what concerns alcohol consumption, excessive consumption is considerable in most parts of the world and responsible for high levels of morbidity and mortality. As OECD (2009a) points out, it is associated with the risk increase of heart stroke and vascular diseases, liver cirrhosis and certain cancers. Foetal exposure to alcohol also raises the risk of birth defects and intellectual capacity. Excessive alcohol consumption is also often associated with death and disability caused by accidents and injuries, and with assault, violence, homicide and suicide. According

[65] OECD (2009) defines alcohol consumption as annual consumption of pure alcohol in litters, per person, aged 15 years and over. However, it is important to mention that the methodology to convert alcoholic drinks to pure alcohol may differ across countries: typically beer is weighted as 4-5%, wine as 11-16% and spirits as 40% of pure alcohol equivalent.

[66] Table 4.4 in Annex 4.A resumes the description of the variables used and their respective source.

to OECD (2009a), it is estimated to cause more than 2 million deaths annually. Nevertheless, like tobacco, it is one of the major avoidable risk factors for disease.

We estimate the health equation using panel data for 17 OECD[67] countries (given by the subscript *i*) for which data are available, over the period 1980-2004. Table 4.1 explains the set of variables used in the empirical approach providing some elementary descriptive statistics.

Table 4.1 – Descriptive statistics of the variables (17 OECD countries, 1980-2004)

Variable	Observations	Mean	Std. Deviation	Coef. Variation	Min	Max
income	425	23774.85	5176.09	0.218	10554.64	40906.35
education	424	10.69	1.61	0.151	6.30	13.40
patents	425	116.73	117.56	1.007	0.10	651.55
med.graduates	296	38.10	17.18	0.451	11.40	121.00
tobacco	264	30.24	7.25	0.240	16.20	50.50
tobacco (females)	264	23.70	7.25	0.306	5.10	45.00
tobacco (males)	264	37.00	11.70	0.316	15.00	70.80
alcohol	418	10.98	2.87	0.261	5.80	19.50
health expend	402	1661.90	869.50	0.523	276.00	6194.00
consultations	342	5.79	2.61	0.451	2.40	14.80
life expectancy (LE)	421	76.80	1.93	0.025	71.40	82.10
LE females	421	79.96	1.81	0.023	74.90	85.60
LE males	421	73.64	2.14	0.029	67.90	78.60
LE at 65 females	421	18.89	1.25	0.066	16.10	23.30
LE at 65 males	421	15.14	1.18	0.078	12.50	18.20

As we can see from Table 4.1, *patents*, *health expend*, *med. graduates* and *consultations* are the variables with higher relative dispersion. All variables are defined in logarithms so we can interpret the estimated parameters as elasticities of life expectancy with respect to each of its determinants.

Having in mind the endogeneity problem, we need to instrument the explanatory variables referred to education and per capita income to obtain unbiased and consistent estimates in the regressions. These two determinants of health status are potentially endogenous since the healthier people are the higher is the possibility to enjoy higher

[67] The countries included in the sample are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, Portugal, Spain, Sweden, United Kingdom and United States.

income and to invest more on education. The endogeneity tests for per capita income and education confirmed that these variables should be treated as endogenous[68]. The adequate estimation method that takes care of this problem is two step GMM using instruments[69]. In a first step, the choice of the instrumental variables was based on the statistical significance (at 1%) of the correlations between the endogenous variables (education and per capita income) and other variables that can serve as instruments, as we can observe from the results reported in Table 4.2.

Table 4.2 – Correlation coefficients of pair of variables

Variable	*income*	*education*	*health expend*	*patents*	*med. graduates*
income	1.000				
education	0.6796*	1.000			
health expend	0.8837*	0.6060*	1.000		
patents	0.6832*	0.7826*	0.5746*	1.000	
med. graduates	-0.1238*	0.0995	-0.3350*	0.1778*	1.000

Based on that criterion, the instruments choice was total expenditure on health (per capita), number of medical graduates[70] per practicing physicians (per million) and the number of patents (per million). A good instrument needs to be correlated with the endogenous variables but uncorrelated with the equation errors. In what concerns total expenditure on health, many empirical studies show a significant link between this variable, per capita income and education (OECD, 2006), although there is no consensus if more health expenditures necessarily imply more health (and so may not

[68] The C-statistic used to test the exogeneity of income and education is 15. 794 (with a p-value of 0.0004) rejecting therefore the null hypothesis. The C statistic (also known as "GMM distance" or "difference-in-Sargan" statistic) allows a test for a subset of the orthogonality conditions, i.e., it is a test of the exogeneity of one or more instruments.

[69] See Baltagi (2005).

[70] According to OECD (2009), medical graduates are the “number of students who have graduated in medicine from medical faculties or similar institutions, i.e., who have completed basic medical education in a given year”. It excludes graduates in pharmacy, dentistry/stomatology, public health and epidemiology and individuals who have completed post-graduate studies or training in medicine.

cause higher life expectancy[71]). Medical graduates represent people who have completed tertiary education in the medical science, reflecting a significant investment in education, which in turn can be associated with more scientific production and higher income level (Soukiazis and Cravo, 2008). The patent ratio is used as instrument for education and income as well, and this is an adequate choice since in the more developed countries higher levels of human capital related to innovation differentiate better these economies. This idea corroborates the empirical study of Soukiazis and Cravo (2008).

Since it is not clear that the instrumental variables are not uncorrelated with life expectancy, in a second step we need to test the validity of the instruments. To do so, we use the Sargan-Hansen test of over-identifying restrictions. The joint null hypothesis is that the instruments are valid (uncorrelated with the error term), and that the excluded instruments are correctly excluded from the estimated equation. A rejection of the null hypothesis questions the validity of the instruments, which was not the case. We also performed tests for the orthogonality and redundancy conditions[72] of the instrumental variables. All the instruments used in our regressions are in fact exogenous and they revealed to be non-redundant, with the exception of medical graduates that revealed to be redundant in the specification of Models (2) and (4), as Table 4.3 shows. As Baum *et al.* (2007) note, "If some of the instruments are redundant then the large-sample efficiency of the estimation is not improved by including them". However, excluding this variable from the instruments the estimation results are not satisfactory for these two models.

Inferences about error autocorrelation and homoskedasticity have been made too. The Wooldridge test for autocorrelation[73] rejects the null hypothesis of error independence, so we had to implement the bandwidth option[74] for correcting this

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[71] See, for instance, Nixon and Ulmann (2006).

[72] As already referred, the C statistic is a test of the exogeneity of one or more instruments and it was implemented using the "orthog" option; the "redundant" option allows to test whether a subset of excluded instruments is redundant (Schaffer, 2007).

[73] xtserial command in STATA implements the Wooldridge test for serial correlation in the idiosyncratic errors of a linear panel-data model. According to Drukker (2003) this test has good properties in samples of moderate size.

[74] We used in our regressions the option bw(#), with # = 5 (around $T^{1/3}$). When the GMM option is combined with the bw(#) option, the estimates are autocorrelation-robust. See Baum *et al*. (2007).

problem. On the other hand, robust standard errors are obtained to take care of error heteroskedasticity. The efficiency of the GMM estimators is checked through the Hansen's J statistic (shown in Table 4.3). The J statistic is consistent in the presence of heteroskedasticity and autocorrelation, testing in the null hypothesis the over-identification of all instruments.

4.5 Empirical results

In this section we report our empirical results (Table 4.3) by applying two step GMM (fixed effects) which are efficient for arbitrary heteroskedasticity and autocorrelation and also gives statistics robust to heteroskedasticity and autocorrelation.

Table 4.3 – Panel regression results from the health status equations (17 OECD countries, 1980-2004)

Variables		Model (1) *Life Expectancy* **(total)**	Model (2) *Life expectancy* **(females)**	Model (3) *Life expectancy* **(males)**	Model (4) *Life expectancy* **at 65 (females)**	Model (5) *Life expectancy* **at 65 (males)**
income		0.0484**	0.0351*	0.1011***	0.0403	0.2896***
		(2.039)	(1.736)	(3.480)	(0.386)	(3.561)
education		0.1479**	0.1559***	0.0465	0.6676**	0.2573
		(2.137)	(2.801)	(0.485)	(2.394)	(0.862)
consultations		0.0201**	0.0283***	0.0071	0.0638**	0.0208
		(2.114)	(4.088)	(0.530)	(2.019)	(0.403)
tobacco		-0.0215***				
		(-3.371)				
alcohol		-0.0147**	-0.0107	-0.0213***	-0.0232	-0.0477**
		(-2.560)	(-1.511)	(-3.185)	(-0.761)	(-1.980)
tobacco (females)			-0.0053		-0.0042	
			(-1.115)		(-0.217)	
tobacco (males)				-0.0264***		-0.0429
				(-3.305)		(-1.325)
Number of observations		163	163	163	163	163
Number of countries		17	17	17	17	17
root mse		0.00468	0.00535	0.00538	0.0187	0.0179
R-squared		0.922	0.853	0.929	0.785	0.903
adjusted R2		0.910	0.830	0.918	0.751	0.888
F test		183.7	71.81	216.1	42.32	184.4
Number of excluded instruments		3	3	3	3	3
Underidentification test (p-value)		0.0530	0.1292	0.0521	0.1292	0.0521
Hansen J statistic (p-value)		0.7909	0.75	0.5019	0.6886	0.2789
Tests for the instruments						
Patents	C statistic (p-value)	0.7909	0.75	0.9263	0.6886	0.425
	IV redundancy test (p-value)	0.005	0.0042	0.0043	0.0042	0.0043
health expend	C statistic (p-value)	0.7909	0.75	0.5019	0.6886	0.2789
	IV redundancy test (p-value)	0.0002	0.0003	0.0001	0.0003	0.0001
med. graduates	C statistic (p-value)	0.7909	0.75	0.5019	0.6886	0.425
	IV redundancy test (p-value)	0.0552	0.1171	0.0426	0.1171	0.0426

Notes:

Robust t statistics in parentheses. ***** p<0.01, ** p<0.05, * p<0.1**

Instrumented variables: income; education.

Excluded instruments: Total expenditure on health per capita; medical graduates, per 1 000 practising physicians; number of patents per 1000 population.

Model (1) is the life expectancy at birth for total population, Model (2) for females, Model (3) for males and Models (4) and (5) are the regressions for life expectancy of elderly people for females and males, respectively.

As can be seen from Table 4.3, all estimated coefficients have their expected sign. Higher income levels, higher education and higher efficiency of the health system (through consultations) affect positively health standards prolonging life expectancy. On the other hand, unhealthy lifestyles related to alcohol and tobacco consumption have damaging effects on health reducing life expectancy. However, not all of the estimated coefficients are statistically significant or have the same impact across different ages or gender.

Life expectancy at birth

In what respects the life expectancy at birth for total population, Model (1), all the explanatory variables considered in the health production function show statistical relevance. The most significant result (at the 1% level) comes from the tobacco variable having its expected negative impact on longevity. It is predicted that a 1% increase in the ratio of population (with 15 years old or over) who are daily smokers is responsible for 0.0215% decrease in life expectancy at birth, everything else remained constant. At the 5% significance level, per capita income and education have a positive effect on life expectancy at birth, while alcohol consumption has a negative impact. Education is the explanatory variable with the greatest impact (in magnitude) on life expectancy. It is predicted that every 1% increase in the average years of schooling (of the population aged 25-64) is associated with 0.1479% increase in life expectancy, assuming that everything else is constant. This is in line with the human capital theory that predicts a strong association between education and health, since more educated people are likely to have safer and better jobs enjoying higher income that permits to have better health care and provision. More educated people are better informed and aware of health risks and are more likely to adapt themselves to a healthier lifestyle (Silles, 2009). New treatments and new developments on the health sector depend highly on the level of education that allows for higher research and innovation in this sector.

These results do not differ significantly from other studies, like those reported recently by Joumard *et al*. (2008), although they used a different methodology and sample size[75].

Life expectancy according to gender

When we analyze life expectancy regressions for females and males, Models (2) and (3) respectively, it is evident that the various explanatory variables play a different role according to gender. In fact, while for females the determining factors of life expectancy are education and consultations (highly significant at 1% level), for males, income and lifestyles (consumption of alcohol and tobacco) are the most important factors, both on magnitude and statistical significance.

These results, although different from those obtained by Jourmad *et al*. (2008)[76], are not surprising. In developed countries there are some health differences between women and men that have been noticed for a long time. It is well known that women have higher life expectancy than men (as OECD (2009) shows) and this is possibly related to a higher impact of the education level and better use of health services as our evidence shows. However, women also experience higher morbidity than men. As Gambin (2005) explains, the types of illness and main causes of death between genders are different: while for men the main causes of death are cardiovascular diseases, cancers and accidents (possibly related to lifestyle and income level as our evidence shows), for women they are breast cancer and cancers of the genitor-urinary system. These facts corroborate with the idea that "women live longer but are sicker than men"[77] which can explain, at least partly, the fact that women are also the ones who make a greater use of health care services and this can be related to educational level.

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[75] Joumard *et al*. (2008) used Generalised Least Square (GLS) methods and health care resources are measured by health practitioners. The sample covers 22 countries.

[76] When they use health spending as a measure of health care resources, the results are very similar across gender and age, with inputs having the expected sign and statistical significance. The exceptions are for tobacco and income that loose the statistical significance for females when life expectancy at birth is considered. At age 65, alcohol has no statistical significance for both men and women. In a similar analysis, but considering practitioners instead of health spending, only alcohol has a different impact at age 65, having statistical significance only for women.

[77] See Börsch-Supan *et al*. (2005).

Regarding the income factor, and in spite of an increasing female participation in labour market mainly in developed countries, there are still important inequalities related to professional opportunities and wages between genders. Studies on labour economics have shown significant differences in earnings between males and females, after controlling for other common characteristics[78]. This fact may help to explain the relative higher explaining power of the income factor on men's life expectancy. On the contrary, the empirical results show that the level of education, although not significant related to men's life expectancy, it is highly significant for women.

In what concerns lifestyles, some risk behaviours like tobacco and alcohol consumption are more prevalent among males. This can be explained by socioeconomic and cultural factors[79]. However, it is also true that since the eighties some significant behaviour changes have been made across gender and countries. Statistics show that between 1980 and 2004, the time period analyzed in this study, the percentage of smokers in the male population of OECD countries declined and the same trend was observed for women too in most countries, with exception of Finland and France. However, since the decline in smoking was more significant for men than for women, the gender gap narrowed: it was 18% in 1980 but had declined to 7% by 2004, as data show for 16 OECD countries, for which unbroken time series are available (OECD, 2006; OECD, 2009).

In what concerns alcohol consumption OECD Health Data does not give information by gender, so we can only analyze trends in alcohol consumption across countries. Statistics show that over the period under analysis there was a reduction in alcohol consumption in the OECD countries, which can reflect a changing of drinking habits that can also be related to a positive impact of several policy measures (such as advertising, sales restrictions and taxation) taken to control alcohol use. Nevertheless, as OECD (2009a) also points out, it has been observed in some countries and social groups (mainly among young males) a raise in consumption of large quantities of alcohol at a single session, called "binge drinking".

[78] See Gambin (2005) for a review.

[79] Sassi *et al*. (2009) suggest that men and women in poor socio-economic conditions may differ in their lifestyle choices. As they point out, rates of smoking or alcohol abuse are higher among men at the bottom of the social scale.

It is important to note that most of the negative consequences of risk behaviours on individuals' health are observed only some years later. In what concerns the alcohol consumption, data show in general, that countries with high levels of alcohol consumption tend to have higher death rates from liver cirrhosis 10 to 15 years later relatively to those with lower levels of consumption. In most OECD countries, death rates from liver cirrhosis have decreased over the past two decades, which can be related to the overall reduction in alcohol consumption (OECD, 2009a).

Life expectancy of the elderly

When we look to the estimation results of Models (4) and (5) explaining life expectancy at age 65 for females and males, respectively, we can conclude that the major determinants of longevity for women and men are different. While for women education and consultations are the most significant factors (at the 5% level), for men per capita income (at the 1% level) and alcohol consumption (at the 5% level) are the major explanatory factors. Some of these results (positive effect of consultations for women, negative impact of alcohol for men) are in line with the tendencies described above concerning the health status of the OECD countries.

However, we should look to these results with some caution since it is after this age that the incidence of various diseases increases sharply as well as the general deterioration of physical robustness, characterizing the biological deterioration process we have already referred. Therefore, it is expectable that at this age, health status of individuals also will reflect the cumulative effects of their lifestyles in earlier periods. This would imply the estimation of a dynamic panel model with a long lag history of the variables used in the health production function reducing the sample size drastically. On the other hand, data relative to tobacco consumption does not provide information about the quantity of cigarettes smoked on average per person but only about the proportion of population who is daily smoker, which is less relevant for the analysis of the impact of smoking on health.

4.6 Chapter concluding remarks

The aim of this chapter was to analyze the main determinants of health status in the OECD countries. Life expectancy at birth and for elderly people (aged 65) was used as a proxy to express health improvements in these countries. Life expectancy was also considered for males and females to verify whether there are differences on the factors explaining health status according to age or gender. A panel data approach was employed to estimate the health equations that take into account the endogeneity of some determinants of health, such as income and education. Two step IV-GMM which is efficient for arbitrary heteroskedasticity and autocorrelation is the adequate technique to obtain more consistent estimates. Our approach considers the endogeneity of some of the determinants of health status, which has not been considered in great deal in the empirical literature. Therefore we think that our reported estimates for late age, although different from others (Joumard *et al.*, 2008), are more reliable.

The health production function approach we use considers health care resources (through consultations), socio-economic factors (such as income per capita and education levels) and lifestyles characteristics (such as tobacco and alcohol consumption) as the main determinants of health status. The number of consultations (per capita) aims to capture the efficiency of human (and equipment) resources in the health system as an alternative to the conventional variables used related to number of physicians, hospital beds, among others. Total expenditure on health (per capita), number of medical graduates and the patents rates (as proxy for innovation) are the variables used to instrument income and education which are assumed (and shown) to be endogenous in the health equation. These instruments, both from the theoretical point of view and by testing their validity are shown to be adequate in the estimation process.

Our empirical analysis shows that all socio-economic and lifestyles factors used (income, education, consultations, tobacco and alcohol consumption) are relevant in explaining life expectancy at birth for total population in the OECD countries. Education is the factor with the highest positive impact on health and non-healthy behaviour reflected in the consumption of tobacco the most significant factor (at the 1% level) with negative impact on life expectancy.

However, when we do the same analysis by gender we obtain different impacts of the explanatory variables. While for women the determining factors of life expectancy are education and consultations, strongly significant at the 1% level; for men, income, alcohol and tobacco are the most important factors explaining life expectancy. These results are in line with the statistical tendencies observed in the OECD data, namely, the higher life expectancy of females which can be attributed to education and better use of health care services, relatively to the lower life expectancy of males which can be due to a higher prevalence of unhealthy lifestyle behaviours.

The same conclusions are obtained with respect to life expectancy of elderly people. Once more, our findings suggest that for women education and consultations are the most significant factors, while for men per capita income and alcohol consumption are the major explanatory factors. However, since the lack of data does not allow us to consider in our estimations the cumulative effects of individuals' lifestyles, we should look to these results with some caution. At the same time, these results evidence the need of more data concerning health conditions of the elderly, allowing for international comparisons.

Our study highlights the reversal causation effects of the main determinants affecting population's health, income level and education. Economic policies have to be implemented aiming to improve the standards of living and narrowing income disparities. Income policies that reduce disparities can have a direct impact in improving health conditions and prolonging life expectancy. Education policies are crucial with this respect affecting both income and health improvements and this has been well developed by the human capital theory. More educated people are wealthier and healthier. Investing on the health sector with the aim to improve efficiency is very important too and economically favourable, creating more jobs and economic activities associated with the health sector. Finally, policies to alter unhealthy behaviour (through taxation, education and better information) are necessary for the sick of better health. It is important to highlight the strong association between health, education and income with cumulative characteristics and the need to develop policies that tackle these areas simultaneously.

Annex 4.A.

Table 4.4 – Description of variables and data sources

Variables		Description	Source
Dependent	***Life Expectancy at birth (total)***	Life expectancy at birth, total population, years	OECD (2009)
	Life Expectancy at birth (females)	Life expectancy at birth, females, years	OECD (2009)
	Life Expectancy at birth (males)	Life expectancy at birth, males, years	OECD (2009)
	Life Expectancy at 65 (females)	Life expectancy at 65, females, years	OECD (2009)
	Life Expectancy at 65 (males)	Life expectancy at 65, males, years	OECD (2009)
Explanatory	***Income***	Real GDP per capita (Laspeyres), RGDPL – dollars in 2000 constant prices	Heston *et al*. (2007)
	Education	Average years of education of population aged 25-64	Arnold *et al*. (2007)
	Consultations	Number of contacts with an ambulatory care physician divided by the population	OECD (2009)
	Tobacco	Tobacco consumption % of population 15+ who are daily smokers	OECD (2009)
	Alcohol	Alcohol consumption, liters per capita (15+)	OECD (2009)
	Tobacco (females)	Tobacco consumption % of females 15+ who are daily smokers	OECD (2009)
	Tobacco (males)	Tobacco consumption % of males 15+ who are daily smokers	OECD (2009)
Instrumental	***Patents***	Number of patents per million of inhabitants aged 25 or over	USPTO (2009)
	Health expend	Total expenditure on health (per capita), US$ purchasing power pari	OECD (2009)
	Medical graduates	Number of students who have graduated in medicine from medical faculties or similar institutions	OECD (2009)

Notes:

Arnold, J.; Bassanini, A.; Scarpetta, S., 2007. Solow or Lucas? Testing Growth Models Using Panel Data from OECD Countries, *Economics Department Working Papers* No. 5, http://www.olis.oecd.org/olis/2007doc.nsf/linkto/eco-wkp(2007)52. Accessed 25 November 2008.

Heston *et al*., 2007, http://pwt.econ.upenn.edu/. Accessed 26 September 2009.

OECD, 2009. OECD Health Data 2009, http://www.oecd.org/health/healthdata. Accessed 12 September 2009.

U.S. Patent and Trademark Office (USPTO), http://www.uspto.gov. Accessed 11 October 2009.

Chapter 5

Health Factors as Determinants of Regional Growth and Convergence. An Empirical Analysis for the Portuguese Districts*

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5.1 Introduction

In this chapter our aim is to analyze the impact of health conditions on economic growth at a regional level in Portugal.

In recent years the Portuguese economy has faced the reinforcement of two major trends: the ageing of its population[80], and the desertification of the *interior* (in-land) regions. As most developed countries, Portugal has an ageing society. Health improvements and better quality of life allow people to live longer; modern lifestyle and increasing female participation in labour markets tend to delay maternity and decisions on the number of children. On the other hand an increasing migration from the *interior* (less developed) to the *littoral* (more developed) regions and from rural to urban areas[81] (with higher job opportunities and better living conditions) has led to the desertification of many *interior* regions (and mainly the rural ones, where population is older and less qualified), often described as "depressed regions"[82].

These trends have important consequences on the growth potentials of the Portuguese regions. The systematic reduction of the proportion of the working age population in the *interior* regions has negative consequences on the creation of economic activities, demand is depressed and this is an important handicap not only for attracting business activities but also for investing in basic infrastructures. On the other hand, as people concentrate on large urban areas in the *littoral* there is strong demand for public infrastructures especially on education and health sectors.

These economic disparities have important consequences on the access to education and health care, two very important aspects of wellbeing. While there have been some

[80] The ageing of population may be defined as the increase over time of the share of people aged 65 and over in the total population of a given area. Given this definition, ageing depends not only on the increase of the elderly but also on the decrease of young people. In Portugal the share of population aged 65 and over was 17.1% in 2006 against 14.9% in 1996. In predominantly rural areas this share was 22.7% in 2006 (Eurostat, 2010).

[81] Urban population has increased steadily in last decades: it was 29.4% in 1980 and 55.1% in 2005 (Campos, 2008). This phenomenon gives rise to many challenges to deal with, such as, the access to basic infrastructures on health, education, transport, security or environmental quality, necessary for a sustainable growth of urban zones.

[82] According to INE (2009), there is a significant heterogeneity in population density between urban areas. Contrasting with the *littoral* urban areas, some capital districts of the *interior* (Bragança, Guarda, Portalegre, Évora and Beja) have a very low population density (bellow 100 inhabitants per km2).

efforts to assure generalized access to primary and secondary education services in all the Portuguese regions, which reflected in a reduction of regional educational disparities in the last years (INE, 2009), the same is not true in what concerns health care. In fact the geographical distribution of health resources is one important issue when we consider health inequalities[83] and it can be a severe restriction to health care access, mainly to the elderly, to whom transport cost and lack of mobility are severe constraints for health care utilization (Santana, 2000). Although relevant improvements were achieved over the last years, and despite the universal and equity goals of the National Health Care System (NHS)[84], there are still inequalities in health services that affect people's lives and their strength to be more productive. One key finding of the WHO (2010) report on the Portuguese health system performance that clearly illustrates this situation is that life expectancy is shorter in the less populated and less urban regions of Portugal.

In what concerns human resources in the health sector, although Portugal has already a number of physicians (per million inhabitants) close to the European average at the end of the period under analysis[85], its distribution is far from being balanced. In fact, according to Doorslaer *et al*. (2004), Portugal is one of the OECD countries where access to doctors and to specialists is more difficult. This is a problem that does not affect exclusively the *interior* districts. The huge increase of urban population has led also to a shortage of family doctors on some Lisbon areas, Setúbal, Oporto and Braga. In fact one feature of the NHS is still the existence of barriers to health care provided by public services, with more than 700 thousand residents without family doctor in 2005 (Campos, 2008).On the other hand, the expected retirement of many physicians will

[83] However, it is important to note that health inequalities may be caused by other reasons, different from geographical ones. To better understand the notion of health inequalities it is worth mentioning that there are different (health) equity concepts (Pereira, 1993). One possible definition refers to "equal resources' access for the same needs" and it takes place when all the consumers, in all districts, have access to the same services at the same cost, both in transport cost and time loss. This definition implies a positive discrimination towards those more disfavored, assuring that they will attend the health care they need (Giraldes, 2002). Social gradients, income and education are among the main determinants of health inequalities (Graham and Kelly, 2004; Marmot, 2005).

[84] This is the spirit of the Law 48/90, 24 August 1990 and the Law 27/2002, 8 November 2002.

[85] According to OECD (2009), the number of practicing physicians per million inhabitants in Portugal was 3.42 in 2006, while the European Union (EU-15) average was 3.48 in the same year.

make this problem more severe. As Or *et al*. (2008) point out, given that there is evidence of a significant link between national or regional health disparities and the amount of medical resources, it is important to note that, if physicians are scarce, access to care will be more difficult for those with socioeconomic disadvantages (due, for instance, to time and mobility costs).

During the period under analysis, and namely in the recent past years, the closure of several primary care emergency services was one of the most polemic government's decisions that caused a great displeasure among local population, justified by efforts to reduce health expenses and to improve at the same time health care efficiency. To a lesser extent the same has happened in some primary schools. Although these decisions were motivated by efficiency goals and cost reduction policies, we may assume that they would have consequences on the human capital efficiency affecting regional economic performance. The increasing returns to scale in these sectors (education and health) can compensate the diminishing returns of physical capital and lead to higher growth, at least in the long-run analysis.

Having this in mind, and in line with the recent growth literature, in this chapter we intend to highlight the role of human capital (once more in a broader perspective that includes both education and health) as a conditioning factor of regional growth. In order to avoid omitted variable bias, physical capital and workforce population are also included in the growth regressions using a panel data approach.

This chapter is organized as follows. Section 5.2 reviews some of the existing literature on regional growth. In sections 5.3, the model, the methodology and the data used are explained, respectively. Section 5.4 presents and discusses the empirical results from the growth regressions. The final section concludes the main findings and suggests some policy recommendations.

5.2 Literature review

Regional growth and the process of convergence have received an increasing interest since the eighties. Some pioneering works on this area are due to Aschauer (1989) and Barro (1991) that tried to relate public investment with economic growth.

Other well-known references on regional economic growth are Barro and Sala-i-Martin (1992) that, using a neoclassical growth model to study the convergence process across 48 states of the USA, found clear evidence of economic convergence; or Sala-i-Martin (1996) that showed empirical evidence of conditional β-convergence across 110 countries (including the OECD sub-sample, states of the USA and prefectures of Japan) and conditional β-convergence was estimated to be close to 2% per year.

In what concerns Europe, the process of economic integration and the goals of economic and social cohesion justify the interest and the development of regional policies with the aim to reduce regional disparities. Within this context, public policies are important in achieving such goals not only within the same country but also across European regions.

González-Parámo and López (2002) analyzed the relationship between public investment and per capita income growth of the Spanish regions for the period 1965-1995. Private and different measures of human capital that encompass health (public investment in education, public investment in health, and the sum of both as a stock variable) were used to explain regional growth. Using an extended Solow growth model and a panel data framework, the authors found that all the estimates were consistent with theory but human capital only has statistical significant when it is approximated by public investment in health or when it appeared as a stock variable (proxied by the share of working-age population with secondary and college studies). They also found that public investment in education is not significant to explain regional growth.

Similar results are reported by Riviera and Currais (2004) that also analyze the Spanish regions to identify how the composition of health spending affects their productivity over the period 1973-1993. Using a panel data framework they found that both education and health capital are not significant in explaining the convergence process between the 17 Spanish regions. These results, as the authors point out, may reflect the fact that the returns of investment in education and health infrastructures emerge only some years later.

Benos and Karagiannis (2009) studied the Greek economy (at NUTS3 level) for the period 1981-2003 and analyzed the relation between education, health and economic growth using random effects and GMM regressions. Their empirical work shows that health care resources (measured by the number of medical doctors) are important predictors of regional economic growth. When they estimated growth equations for poor and rich regions they found that while for poor regions health was more important for growth than education, the opposite was true for the richer ones. Taking into account these results, the authors suggest that policy-makers should invest on education and healthcare, proportionally more in education in wealthier regions and in health in poor ones to enhance higher growth.

In spite of the existence of a broad literature analyzing regional growth in Portugal and economic disparities, most studies only consider the traditional human capital variable (education). Some recent studies include Freitas *et al*. (2005), Crespo and Fontoura (2009), Martins and Barradas (2009) and Soukiazis and Antunes (2011).

Freitas *et al*. (2005) studied the impact of Portuguese domestic policies on regional economic cohesion for the period 1990-2001 at NUTS2 level. The authors notice that during this period only Algarve and Norte regions grew faster than the country average (both in terms of gross value added per capita and per working age person). They also evidence the strong asymmetries between NUTS2 regions.

Crespo and Fontoura (2009) analyzed the main factors explaining the similarity in productive structures at a regional level (municipal level). Their empirical results show that geographical proximity, a common boundary, similar physical and human capital endowments, economic centrality and market dimension play an important role explaining the similarity in productive structures at this regional level.

Martins and Barradas (2009) studied the convergence process across the Portuguese regions (at NUTS2 and NUTS3 levels) for the period 1995-2006. They highlight the strong asymmetries across regions where Great Lisbon, Great Porto and Peninsula of Setúbal (that correspond to 4.1% of the total area) are responsible for 38.4% of employment and 48.6% of gross value added in 2006. The contrast between *littoral* and *interior* is also very clear: according to the same authors, the *littoral* (32.5% of the total area) hosts 78.8% of the population and it is responsible for 79.2% of employment and 83.6% of gross value added, in the same year.

Soukiazis and Antunes (2011) studied the convergence process across the 30 NUTS3 Portuguese regions for the period 1996-2005. Using a panel data framework and GMM regressions they found an important and statistically significant link between regional economic growth and the employment share in the secondary sector but not in the service sector. Trade and openness are also relevant factors to explain regional growth. The dichotomy between *littoral* and i*nterior* is important for understanding the persistence of regional disparities: *littoral* regions have better standards of living, are more open to trade being more heterogeneous in terms of per capita income. Educational disparities are not significant between the two groups of regions. The authors emphasize the need to develop policies aiming to invert the deindustrialization tendency by reallocating resources to industry and manufacturing (tradable sectors) in order to achieve higher regional growth in Portugal.

In all the above studies health factors have not been considered in great deal to explain growth. One of the reasons that may partly explain the lack of studies that consider health capital for explaining regional growth is the unavailability of data at a regional level. Our study aims to fill this gap by considering 18 Portuguese districts[86], since this is the level recommended as appropriate to analyze health related conditions and inequalities (Oliveira and Bevan, 2003).

[86] Portuguese districts correspond to health sub-regions (see Figure 5.1 in the Annex 5.A).

5.3 Model, data and methodology description

The model

In this study we employ the MRW (1992) approach (as explained in section 2.5.1.) that includes physical and human capital as the main sources of growth. Human capital is influenced by both education and health factors that increase its productivity. The model assumes increasing returns to scale stemming from the broader notion of human capital that compensate the decreasing returns of physical capital accumulation as the Solow's model defined. Having in mind the need to control for individual effects (Islam, 1995), we use a panel data set that includes all the 18 Portuguese districts (also classified as sub-regions) over the period 1996-2006, where data is available for all units.

The estimated growth equation can be specified as follows:

$$\Delta \ln y_{i,t} = b \ln\left(y_{i,t-1}\right) + c_1 \ln\left(Popover65_{i,t}\right) + c_2 \ln\left(Education_{i,t}\right) + c_3 \ln\left(Employ_{i,t}\right) + \\ + c_4 \ln\left(Energy_{i,t}\right) + c_5 \ln\left(Birth_{i,t}\right) + c_6 \ln\left(\Pr escription_{i,t}\right) + c_7 \ln\left(Doctratio_{i,t}\right) + \varepsilon_{i,t} \tag{5.1}$$

where $\varepsilon_{i,t} = \alpha_i + u_{i,t}$, with α_i denoting the regional-specific effects or measurement errors and $u_{i,t}$ referring to the idiosyncratic error term.

The dependent variable (*Yi,t*) is the annual growth rate of per capita income of the district *i* at time *t*. Since we have no data on income at districts level, we had to make some adjustments from the existing data for NUTS3 regions, as explained in the Annex A.5. (Table 5.6); *Popover65*$_{i,t}$ represents the percentage of population with age 65 and over on total population; *Education*$_{i,t}$ is the transition/conclusion rate of secondary school; *Employ*$_{i,t}$ is the number of employees that work on business establishments of district *i*; *Energy*$_{i,t}$ is total electricity consumption[87] (all sectors of activity) by district; *Birth*$_{i,t}$ denotes the number of newborns per million inhabitants; *Prescription*$_{i,t}$, is the

[87] A source of omitted variable bias can exist since data on physical capital are not available at districts level. To avoid this problem, total electricity consumption is used as proxy for physical capital in the growth equation.

number of per capita medical prescriptions; and $Doctratio_{i,t}$ is the number of inhabitants per doctor reflecting human resources devoted to health care[88].

Data explanation and expected results

The first explanatory variable is the log of initial per capita income (lagged one period) known as the convergence factor. If a negative and statistically significant relation is established between the growth of per capita income and its initial level then the convergence hypothesis is confirmed meaning that poor regions grow faster than the richer ones (Barro and Sala-i-Martin, 2004).

The standard growth regressions usually take into account the population growth rate. Since one main demographic characteristic of the Portuguese regions is the ageing of its population (more pronounced in the *interior* and rural regions), it is pertinent to evaluate its impact on regional growth. It is expected a negative correlation between the growth of per capita income and elderly population since this fraction stays out of work and health expenses and social benefits are higher with respect to this population. On the other hand, the higher the elderly population the lower the fertility rate and this is a serious handicap for the modern economies. In an alternative specification of the model, instead of $Popover65_{i,t}$ we use the dependency ratio ($Dependency_{i,t}$), which gives the proportion of dependent people (not at working age, under 15 and with 65 or more years old) relative to economically active population (people between 15 and 64 years old).

Employment is a factor of production and thus it may contribute to growth and development. The number of workers on business establishments is used to measure the impact of employment on regional growth. These data are available on *Quadros de Pessoal* and the differences are once more significant between the *littoral* and the *interior* districts, as it is shown in Table 5.7 in the Annex 5.A. Job creation is higher in the *littoral* (the more developed regions) attracting a significant proportion of active population. This employment factor captures not only the potential of labor markets but also the dynamics of business activities in each district. As a proxy for physical capital at the district level we used total electricity consumption (all sectors of activity) by

[88] The description of all the variables used in our model and the data sources are explained in Table 5.8 in the Annex A.5.

district. We expect that both *Employ* and *Energy* have a positive impact on regional growth.

Another important factor strongly related with income is the access to education. It is worth mentioning that educational asymmetries (mainly at primary and secondary levels) have been significantly reduced in the last decades, as the statistics of INE (2007) show. The success rate in secondary school is used as proxy for human capital qualifications[89]. It is expected that the educational rate affects positively regional growth as human capital theory predicts.

In what concerns the health sector, Portugal has made strong efforts to improve health standards through the NHS. Remarkable results have been achieved in the increase of life expectancy and the reduction of infant mortality rate and Portugal is among the top of the European countries with the best rates on this last indicator[90]. Despite of the progress made in the health sector, several studies point out Portugal as the country with more inequalities on the access to health care (Doorslaer *et al.*, 2004; Looper and Lafortune, 2009), and the most recent WHO (2010) report also evidenced this problem. In our model, and having in mind the availability of health data at the districts level, we use three proxies to evaluate the status of the health sector in Portugal: (*i*) the birth rate, considered as a key factor of a sustainable demographic growth of a country in the long run, showing a strong downward trend that makes Portugal one of the European countries (EU-27) with the lowest birth rates (Eurostat, 2010); (*ii*) the number of per capita medical prescriptions and (*iii*) the number of inhabitants per doctor. The impact of the second health proxy on growth is dubious. Higher medical prescriptions could imply better treatments and higher access to medical care having positive effects on growth. On the other hand, it could mean a less healthy population influencing negatively economic growth. The estimation approach will identify the predominant impact. The third health proxy (*Doctratio*) is a measure of the availability of human resources in the health sector. The higher the ratio of inhabitants per doctor the less are the medical resources available and the access to health services

[89] Since data on scholar success rate in high school is only available at the NUTS3 level, the same adjustments were made as with income per capita for the districts, explained in the Annex 5.A.

[90] Life expectancy at birth has increased significantly from 71.4 in 1980 to 79.1 in 2007 and this is very close to the EU15 average; infant mortality is one of the most remarkable results achieved: in 1980 this rate was one of the highest among the EU-15 countries (24.2 deaths per 1000 born), but in 2007 declined to 3.4 that is below the EU-15 average (OECD, 2010; WHO, 2010).

is more difficult (especially for those with lower socioeconomic status, as Or *et al*. (2008) note). It is expected that this variable has a negative impact on growth.

In order to highlight socioeconomic disparities between the *interior* and the *littoral* districts, Table 5.1, Table 5.2 and Table 5.3 summarize the data used in the growth model to estimate concerning the whole sample, the *littoral* and the *interior* regions, respectively. As can be seen, differences are significant between these two geographical areas that justifies the estimation of two separate growth models.

Table 5.1 – Descriptive statistics of the variables (18 Portuguese districts, 1996-2006)

Variable	Observations	Mean	Std. Deviation	Coef. Variation	Min	Max
Income $_{pc}$	198	12.339	12.399	0.995	7.320	25.465
WorkagePop	182	65.80	2.606	25.249	60.9	70.7
Popover65	182	19.23	4.190	4.589	10.6	26.1
Education	198	64.69	3.584	18.050	55.48	73.41
Employ	198	144767.6	185608	0.780	11444	841178
Energy	198	1.59e+09	1.67e+09	0.952	1.25e+08	7.14e+09
Birth	198	9.76	1.624	6.010	6.5	13.7
Prescription	198	5.480	1.450	3.779	2.9	8.8
Doctratio	198	529.066	188.217	2.811	120	851

Table 5.2 – Descriptive statistics of the variables (*littoral* districts, 1996-2006)

Variable	Observations	Mean	Std. Deviation	Coef. Variation	Min	Max
Income $_{pc}$	110	13.836	3.779	3.661	8.189	25.465
WorkagePop	101	67.61	1.673	40.412	64.9	70.7
Popover65	101	16.50	3.067	5.380	10.6	21.3
Education	110	65.33	3.671	17.796	56.19	73.41
Employ	110	233363.1	210297.6	1.110	38801	841178
Energy	110	2.57e+09	1.68e+09	1.530	3.92e+08	7.14e+09
Birth	110	10.80	1.315	8.213	7.8	13.7
Prescription	110	5.457	1.350	4.042	3.6	8.2
Doctratio	110	457.190	203.623	2.245	120	761

Table 5.3 – Descriptive statistics of the variables (*interior* districts, 1996-2006)

Variable	Observations	Mean	Std. Deviation	Coef. Variation	Min	Max
***Income** $_{pc}$*	88	10.604	1.629	6.510	7.320	14.510
WorkagePop	81	63.55	1.612	39.423	60.9	67.3
Popover65	81	22.62	2.637	8.578	16.5	26.1
Education	88	63.90	3.324	19.224	55.48	72.57
Employ	88	34023.27	16443.36	2.069	11444	85351
Energy	88	3.62e+08	1.82e+08	1.989	1.25e+08	9.57e+08
Birth	88	8.47	0.875	9.680	6.5	10.5
Prescription	88	5.508	1.574	3.499	2.9	8.8
Doctratio	88	618.909	116.504	5.312	370	851

As the Tables above show there are sharp differences between *littoral* and *interior* districts. As we can see, the *interior* districts show on average higher ratios of ageing population, lower birth rates, lower levels of employment and per capita income and face a more pronounced lack of physicians. The descriptive analysis of the variables' statistics also shows that education is one important dimension where the asymmetries are not relevant.

Methodology

There are several methods available to panel data estimations, and the first step is to decide whether fixed or random effects are more appropriate. In our model the random effects hypothesis is not a good choice because it assumes that individual unobserved effects are not correlated with the explanatory variables, which is not a reasonable assumption when we are analyzing regions with large asymmetries. Performing the Hausman test[91] we confirmed that the fixed effects model is the most appropriate.

A problem with the estimation of the growth model is the endogeneity of the regressors which is pertinent in the case of the lagged per capita income. Another source of endogeneity is due to reverse causality between income, education and health, as already discussed in previous chapters. If we ignore this problem the obtained estimates will be biased and inconsistent. According to Bond *et al*. (2001), the use of difference GMM techniques avoids the problem of omitted variables that are constant over time

[91] The Hausman statistics tests the random effects against fixed effects.

(unobserved individual-specific effects) and so estimates will no longer be biased. On the other hand, the use of instrumental variables allows parameters to be estimated consistently in models that include endogenous right-hand-side variables even in the presence of measurement error.

Having this in mind, we report results estimating the growth equation by fixed effects and GMM as more appropriate to the dynamic panel models. The comparison of the results will show the dimension of bias and inconsistency due to the endogeneity problem.

Having observed significant differences between the *interior* and the *littoral* districts we also want to implement two different estimations with respect to these two distinct areas[92]. However, since this division results in a small number of regions (small *N*) and total observations (*T* is also low), GMM methods are no longer an option (Bond *et al*., 2001). When the time series are persistent and the number of time series observations is small, the first difference GMM is poorly behaved because lagged levels of variables are weak instruments for subsequent first-differences. Therefore, in this case we report results only from fixed effects estimations.

We used the Wooldridge test for checking the problem of serial correlation in the fixed-effects models and the null hypothesis of error independence was not rejected. We also performed a Likelihood-ratio test to check for homoskedasticity which confirmed not to be the case; therefore we report robust standard errors in the estimations.

[92] As explained before, using this geographical criterion is almost equivalent to distinguishing between rich and poor regions (with a per capita income above and below the country's average, respectively).

5.4 Empirical results

We start our empirical analysis by presenting in Table 5.4 the results from the estimation of growth models at the district level using panel data for the period 1996-2006, emerged from fixed effects regressions (the first three columns) and GMM regressions (the last three columns).

The first aspect to notice is that the coefficient of the initial per capita income (convergence factor) is negative and statistically significant in all regressions and this is evidence that a convergence process has been taking place across the Portuguese districts.

In what concerns the fixed effects regressions, with the exception of $Birth_{i,t}$ (with no statistical significance), all the explanatory variables considered in the growth regression have their expected sign and show statistical significance, except $Education_{i,t}$, and $WorkagePop_{i,t}$. It was not possible to establish a significant correlation between income growth and education although this variable carries its expected sign. This can be partly explained by the kind of information given by the proxy used for education (transition/conclusion rate of secondary school), more quantitative than qualitative. Although $WorkagePop_{i,t}$ has no statistical significance in Model (2), and so it doesn't add much explanatory power to models (1) and (3), we opted to report it for allowing a direct comparison with the obtained GMM results.

Table 5.4 – Growth regressions at the district level. Panel data, 1996-2006

Variables	*Fixed Effects*			*GMM*		
	Model (1)	**Model (2)**	**Model (3)**	**Model (1)**	**Model (2)**	**Model (3)**
ln(Y) $_{i,t-1}$	-0.3277*** (-6.054)	-0.3343*** (-5.333)	-0.3346*** (-6.849)	-0.5468*** (-5.175)	-0.4243*** (-4.295)	-0.4466*** (-5.556)
ln(Education) $_{i,t}$	0.0167 (0.301)	0.045 (0.556)		-0.078 (-0.793)		
ln(WorkagePop) $_{i,t}$		0.1016 (0.301)		1.4552* (1.763)	1.6850** (2.159)	
ln(Popover65) $_{i,t}$	-0.1634** (-2.215)		-0.1690** (-2.375)			
ln(Dependency) $_{i,t}$						-0.4674* (-1.777)
ln(Employ) $_{i,t}$	0.0286 (0.64)		0.0294 (0.663)			
ln(Energy) $_{i,t}$	0.1406*** (2.614)	0.1263** (2.324)	0.1443*** (2.766)	0.2643*** (2.9)	0.2013* (2.081)	0.2190** (2.738)
ln(Birth) $_{i,t}$	-0.0344 (-0.870)	-0.0071 (-0.188)	-0.0358 (-0.915)	0.2221*** (3.872)	0.2004*** (3.233)	0.1886*** (3.103)
ln(Prescription) $_{i,t}$	-0.0864*** (-4.430)	-0.0961*** (-5.740)	-0.0840*** (-4.731)	-0.0842*** (-3.801)	-0.0809*** (-3.350)	-0.0877*** (-4.080)
ln(Doctratio) $_{i,t}$	-0.1218*** (-3.629)	-0.1305** (-2.857)	-0.1207*** (-3.629)	-0.2707** (-2.569)	-0.2517* (-1.955)	-0.2409* (-2.032)
Constant	-1.0079 (-1.235)	-1.39 (-0.729)	-0.9986 (-1.228)			
Number of districts	18	18	18	18	18	18
Observations	164	164	164	130	130	130
F test	14.69	22.77	16.89	10.98	9.86	10.35
R2 overall	0.00688	0.0018	0.00719			
Hausman test	Chi2(8) = 51	Chi2(8) = 47.47	Chi2(7) = 53.43			
Prob>chi2	0.000	0.000	0.000			
Hansen test				10.57	7.38	8.9
Hansen p-value				0.158	0.287	0.179
AR(2)				0.786	0.767	0.804
AR(2) p-value				0.432	0.443	0.421

Notes:

The dependent variable is the annual growth rate of per capita income.

Hausman statistic tests random effects against fixed effects. Hansen statistictest is the test of over-identifying restrictions in the GMM estimation. AR(2) is the Arellano and Bond test for second order serial autocorrelation in first differences. Numbers in brackets are t-ratios. ***** p<0.01, ** p<0.05, * p<0.1**

As Table 5.4 shows, the most significant factors affecting districts' growth are related with energy consumption (proxy for capital stock) and health factors (significant at the 1% level). As expected energy consumption is positively related to districts' growth, showing that a 1% increase in energy consumption contributes to 0.14%

increase in regional growth, all other things being constant. As we explained before this variable aims to capture the effects of potential business dynamics on growth, which is confirmed in this regression. In the absence of data on capital stock, energy consumption can be considered a good proxy, highly associated with the accumulation of investment goods. Per capita medical prescriptions have a negative impact on districts income growth (with elasticity equal to -0.09%) favoring the view that this variable reflects a less healthy population which affects labour strength and involves higher health expenses. In fact, this result is in line with statistical evidence showing an increase in the level of per capita medical prescriptions in Portugal, which contributes to higher public health expenditure on medication[93]. The ratio of inhabitants per doctor also has a negative impact on growth (with elasticity equal to -0.12%), as expected. This can be taken as evidence that a shortage of human resources in the health sector to satisfy the health needs of the districts' populations has negative consequences on growth.

As expected, ageing population also affects negatively (significant at the 5% level) the districts' growth, being a serious shortcoming and suggesting that incentives are needed to increase fertility and reverse the ageing tendency of the population. Our results show, that when the proportion of the population aged over 65 increases 1% regional growth decreases by 0.16%, all other things being constant. According to the OECD (2010), Portugal has the 8th oldest population in the world and this has negative consequences not only on income, but also on the labour market efficiency and above all on higher health and social costs.

In the GMM estimations we opt to exclude the $Employ_{i,t}$ variable since it had (once more) no statistical significance and to avoid a larger number of instruments. Instead of using $Popover65_{i,t}$, we opt to consider the ratio of the working age population ($WorkagePop_{i,t}$), aiming to capture to some extent the impact of the working force potential availability (models (1) and (2)) and, alternatively, the impact of an ageing population (proxied by the dependency ratio) on regional growth.

GMM results also confirm the convergence process among the Portuguese regions, showing a higher speed of convergence (a common result in GMM estimations). They also highlight the importance of the energy consumption and the demographic structure as good predictors of regional growth (although losing some statistical significance in

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[93] On this issue, see Europe Economics (2005) or Barros and Nunes (2011).

some of the models). In fact, energy consumption and birth rate positively affect regions' growth in Portugal. An important result to notice, when comparing with the fixed effects results, is that the $Birth_{i,t}$ variable gains explanatory power (at the 1% level), pointing out once more the economic importance of the population structure in a country's performance. Portugal has one of the lowest fertility rates of the EU-27 (1.33 in 2007 against an average rate of 1.55 in EU-27, according to the Eurostat (2010)) and, as the INE (2011) statistics show, all over the period 2000-2009, the Portuguese total fertility rate was below its replacement level[94] in all regions.

GMM regressions also confirm the negative impact of prescriptions and doctors ratio on regional income growth. Regarding the prescription variable's marginal impact and statistical significance, they are very similar with that found in the fixed effects regressions. With respect to doctors' ratio, the magnitude of its impact on growth is higher than in the fixed effects regression but its significance level is lower. There is also evidence, from Model 3, of the negative impact of the dependency rate on regional growth, which is an expected result. Since the fertility rate in Portugal is very low, the increase in the dependency rate is mainly due to the ageing of the population. This trend involves higher health and social security costs which affect negatively growth performance in Portugal.

Empirical evidence from the littoral and interior districts

Table 5.5 presents separate growth regressions for the *littoral* and the *interior* districts. The aim is to verify whether there are differences in the growth processes between these two main areas, the *littoral* being more developed than the *interior*.

[94] A fertility rate of 2.1 is assumed as ensuring the replacement of the previous generation and so allowing for the population stability.

Table 5.5 – Growth regressions for the *littoral* and *interior* districts. Panel data, 1996-2006, fixed effects regressions

Variables	*Littoral*		*Interior*	
	Model (1)	**Model (2)**	**Model (1)**	**Model (2)**
$ln(Y)_{i,t-1}$	-0.3460*** (-6.234)	-0.3275*** (-7.169)	-0.5320*** (-5.792)	-0.5377*** (-6.182)
$ln(Education)_{i,t}$	-0.0356 (-0.593)			
$ln(Popover65)_{i,t}$	-0.1449** (-2.057)	-0.1458** (-2.079)	-0.3323* (-2.210)	
$ln(Dependency)_{i,t}$				-0.4384** (-2.829)
$ln(Employ)_{i,t}$	-0.0243 (-0.423)	-0.0282 (-0.495)	0.1485* (2.011)	0.1133 (1.664)
$ln(Energy)_{i,t}$	0.1434** (2.458)	0.1393** (2.415)	0.3619*** (7.009)	0.3359*** (7.739)
$ln(Birth)_{i,t}$	-0.0554 (-1.369)	-0.0565 (-1.405)	0.1256** (2.437)	0.1478** (2.911)
$ln(Prescription)_{i,t}$	-0.0765*** (-3.794)	-0.0811*** (-4.368)	-0.0532 (-1.601)	-0.0610* (-2.008)
$ln(Doctratio)_{i,t}$	-0.0715 (-1.665)	-0.0731* (-1.714)	-0.0104 (-0.221)	-0.021 (-0.540)
Constant	-0.6304 (-0.756)	-0.67 (-0.810)	-6.4438*** (-7.662)	-6.8027*** (-8.463)
Number of districts	10	10	8	8
Observations	91	91	73	73
F test	22	25.32	213.08	99.87
R2 overall	0.0134	0.0151	0.0038	0.00559
Hausman test	Chi2(8) = 43.96	Chi2(7) = 45.08	Chi2(7) = 29.55	Chi2(7) = 29.84
Prob>chi2	0.000	0.000	0.000	0.000

Notes:

The dependent variable is the annual growth rate of per capita income.

Hausman statistc tests the random effects against fixed effects hypothesis. Numbers in brackets are t-ratios. ***** p<0.01, ** p<0.05, * p<0.1**

Our results evidence that the convergence factor (lagged per capita income) is one of the most significant for both groups of regions. However, the speed of convergence is higher among the interior districts than in the *littoral* ones. Therefore, different forces are in action to bring the economies closer to each other.

The energy consumption is another significant factor in the distinct areas. Energy consumption affects positively both areas, but its marginal impact and significance level are higher in the interior districts.

In what respects the employment factor in business establishments, it is shown to be significant and positively affecting regional growth, only in the districts of the interior (Model 1). It is important to notice that the same variable was not significant in the regressions where all the districts were considered.

These results also evidence that health factors play a different role in the two distinct areas. While for the *littoral* districts the determining health factor is per capita prescription (with a negative impact and significance at the 1% level), for the *interior* districts the birth rate is the most relevant factor (at the 5% level) affecting districts growth. This is an expected result, knowing that the proportion of elderly population is higher and the birth rate is lower in the *interior*. In spite of having significance only at the 10% level, the prescription variable is also important in explaining regional growth in the *interior* area, with its negative impact on regional growth (Model 2). As in all the other cases, this result shows the harmful consequences of a less healthy population on regional growth performance. Despite of the fact that the doctors' ratio has its expected negative impact on regional growth, it is found to be significant only in the *littoral* zone (Model 2), the most populated area with higher needs of health care.

Once more it was not possible to find any significant evidence of the relevance of the education variable. Although the results of the separate main areas at the district level are interesting, the conclusions should be interpreted with caution due to the small sample size considered in these panel regressions.

5.5 Chapter concluding remarks

In this chapter our main aim was to provide additional evidence on the determinants explaining regional growth in Portugal. Having in mind two main trends of the Portuguese economy – the ageing of the population and a strong dichotomy between *littoral* (the most developed regions) and the *interior* (the "depressed" regions) – and their consequences on the demand for public health care services, we estimated a growth model that takes into account factors related to health care, in addition with other demographic and economic determinants.

The estimation approach is based on panel regressions that more properly control for specific differences between the analyzed districts. Separate growth equations are used to explain different growth performance of the *littoral* (the developed districts) and *interior* (the less developed ones) with distinct socio-economic characteristics. GMM estimations for the whole sample take into account the endogeneity problem of some regressors.

In spite of some data restrictions that conditioned our empirical analysis and in a certain way may weaken our results, we can still make interesting inferences. Besides the expectable significant impact of the convergence factor, we found that proxies for the economic activity such as energy consumption play an important role in explaining the districts' growth process.

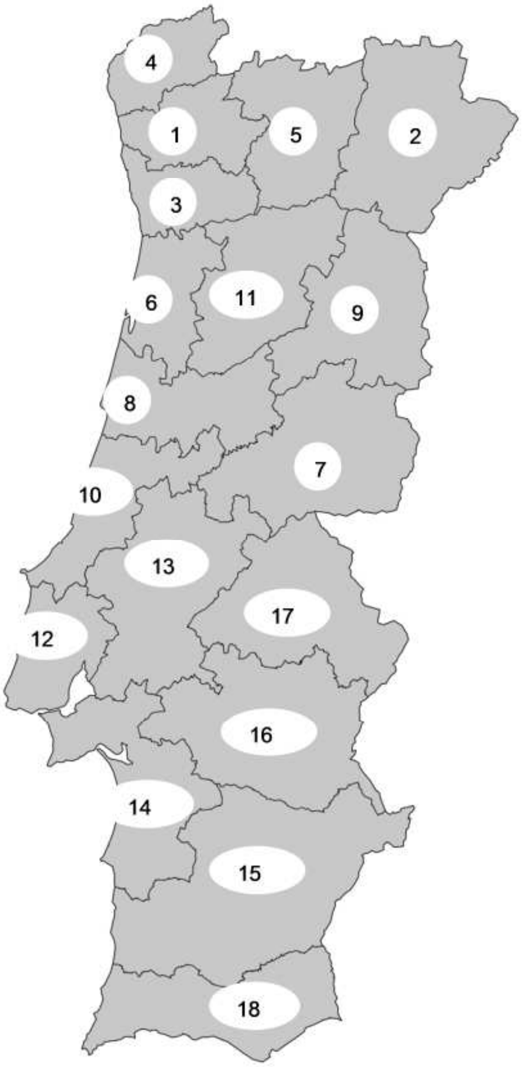
Our evidence also shows that demographic and health factors play a critical role on regional growth. As expected, the ageing of population, reflected by an increase of the dependency ratio, has a significant negative impact on regional growth and this impact will be stronger in the long run if measures are not taken to improve the fertility rate. Therefore, policy-makers should pay much more attention to this issue. Reducing cost strategies that affect fertility rates are not efficient and will be costly in the future. On the contrary, incentives to increase fertility and reverse the ageing tendency of the population are urgent. Our results confirm a positive and significant impact of an increase in the birth rate on districts' economic growth.

We also evidence that the availability of doctors and the per capita prescriptions (this last one can be seen as a proxy for population's health status) are good predictors of regional growth. The higher ratio of inhabitants to doctors reflects more difficulties in accessing health care services and this is a common problem to most rural and more isolated areas but also to the more populated urban areas. This result also points out the need to develop policies with the aim to assure basic health care to those who need more. On the other hand, the significant and negative impact of medical prescriptions (that affects especially the *littoral*) can be taken as evidence of the "unhealthy" status of the population and this should also be a matter of concern.

Lastly, it was not possible to obtain evidence of a relevant relationship between district's growth and education. One explanation could be the adequacy of education data. The other could rely on the fact that health status predominates in explaining regional growth.

Annex 5.A.

Figure 5.1 – Portuguese districts



NUTS2 Regions Continent	Districts (sub-regions)	
Norte	***(1)***	Braga
	(2)	Bragança
	(3)	Porto
	(4)	Viana do Castelo
	(5)	Vila Real
Centro	***(6)***	Aveiro
	(7)	Castelo Branco
	(8)	Coimbra
	(9)	Guarda
	(10)	Leiria
	(11)	Viseu
Lisboa e Vale do Tejo	***(12)***	Lisboa
	(13)	Santarém
	(14)	Setúbal
Alentejo	***(15)***	Beja
	(16)	Évora
	(17)	Portalegre
Algarve	***(18)***	Faro

Source: Google's maps.

Table 5.6 – Territorial adjustment (approximation) between districts and NUTS3

Districts	NUTS III
Aveiro	Entre Douro e Vouga; Baixo Vouga
Beja	Baixo Alentejo
Braga	Cávado; Ave
Bragança	Alto Trás-os-Montes
Castelo Branco	Pinhal Interior Sul; Cova da Beira; Beira Interior Sul
Coimbra	Baixo Mondego; Pinhal Interior Norte
Évora	Alentejo Central
Faro	Algarve
Guarda	Beira Interior Norte; Serra da Estrela
Leiria	Pinhal Litoral; Oeste
Lisboa	Grande Lisboa
Portalegre	Alto Alentejo
Porto	Grande Porto; Tâmega
Santarém	Médio Tejo; Lezíria do Tejo
Setúbal	Península de Setubal; Alentejo Litoral
Viana do Castelo	Minho-Lima
Vila Real	Douro
Viseu	Dão-Lafões

Table 5.7 – Descriptive statistics of the variables according to districts, 1996 and 2006

	Income		**WorkagePop**		**Popover65**		**Education**		**Employ**		**Energy**		**Birth**		**Prescription**		**Doctratio**	
	1996	**2006**	**1996**	**2006**	**1996**	**2006**	**1996**	**2006**	**1996**	**2006**	**1996**	**2006**	**1996**	**2006**	**1996**	**2006**	**1996**	**2006**
Interior (average)	**9.1562**	**11.8109**	**63.99**	**63.50**	**20.69**	**23.75**	**66.52**	**68.32**	**26734.00**	**39952.88**	**596583571**	**917741487**	**8.63**	**7.49**	**3.88**	**6.98**	**739.25**	**517.38**
Bragança	8.1541	10.5609	64.80	63.50	20.2	25	66.06	65.12	11444	20357	125468076	231805695	8.3	6.5	2.9	5.8	851	571
Vila Real	8.0758	10.5133	66.60	66.30	16.5	20.6	65.01	67.62	21453	37662	178175920	338360996	9.3	7.4	3.4	6.4	738	436
Castelo Branco	9.5325	11.7006	62.60	62.60	23.3	25.5	65.59	67.99	37242	44873	349428323	546841774	8.2	7.4	3.9	7.1	707	530
Guarda	7.3197	10.2590	62.50	63.00	22.6	25.2	68.19	68.00	24506	33839	203166449	327864704	8.1	6.7	3.6	6.5	764	556
Viseu	8.1576	10.7886	65.30	65.50	17.1	20	62.55	70.91	51800	85103	528867931	957234370	9.9	8.3	3.5	6.5	707	566
Beja	10.6407	14.5098	63.60	62.70	21.6	24.2	65.52	68.90	18547	30116	276505031	431762568	8.1	7.9	4.3	7.2	849	626
Évora	10.4379	13.0953	64.40	63.10	20.7	23.6	66.63	70.38	29415	42275	274500546	450391650	8.80	8.60	5.2	8.2	612	484
Portalegre	10.9309	13.0594	62.10	61.30	23.5	25.9	72.57	67.63	19465	25398	184535733	305490629	8.30	7.10	4.2	8.1	686	370
Littoral (average)	**12.09419**	**14.38468**	**67.70**	**67.21**	**15.00**	**17.56**	**66.71**	**69.22**	**193704.80**	**267137**	**2003754294**	**3049841584**	**11.09**	**9.44**	**4.05**	**6.78**	**514.88**	**419.2**
Braga	10.19590	11.57664	68.30	69.70	10.6	12.7	72.49	71.88	209169	268000	1841433410	2537820902	13.7	10.2	3.8	6.5	700	551
Porto	12.0837	13.2468	69.70	69.50	11.2	13.8	67.64	71.26	428656	571325	3716860926	5445728882	12.7	10.2	3.7	6.4	249	222
Viana do Castelo	8.1890	9.7472	65.50	65.70	17.6	20.7	72.49	69.74	38801	59132	392262791	668472695	9.6	7.8	3.6	6.9	761	451
Aveiro	11.8973	13.1783	68.80	68.60	12.8	15.7	61.78	71.23	185267	226473	2164877601	3254429087	12.1	9.1	4.1	7.3	647	551
Coimbra	10.8669	13.5531	66.80	65.70	17.8	20.7	62.92	69.61	77981	107607	1458289688	2283418939	9.8	8.5	4.2	7.2	141	124
Leiria	11.9400	14.4560	67.20	66.40	16	18.5	62.75	69.57	97355	150834	1192663767	1953762464	10.7	9.6	4.5	7.7	729	651
Lisboa	19.6367	25.2232	69.60	67.20	14.8	17.3	68.80	69.16	613667	841178	4644316522	7144655171	10.9	11.2	4	6.2	182	177
Santarém	11.5402	13.2035	65.70	64.90	19.2	21.3	69.83	68.71	80474	120982	1034376305	1632298991	9.2	8.9	4.5	7.5	710	645
Setúbal	11.2690	12.9335	70.70	68.30	13.1	16.1	64.64	66.73	130202	183243	2837157273	4233684733	10.7	11.2	3.7	6.2	491	462
Faro	13.3232	16.7285	65.40	66.10	18.3	18.8	63.75	64.32	75476	142596	755304658	1344143979	10.70	11.40	3.7	5.9	479	358

Table 5.8 – Description of the variables and data sources

Variables	Description	Source
Income $_{pc}$	per capita income (thousand euros per inhabitant, deflated by CPI NUTS2, 2008=100)	INE[(1)]
Education	transition/conclusion rate of secondary school	GEPE[(2)]
WorkagePop	percentage of working age population on total resident population by district	INE
Popover65	percentage of resident population with age 65 and over on total resident population by district	INE
Employ	number of employees that work on business establishments by district	MTSS[(3)]
Energy	total electricity consumption (all sectors of activity) by district	DGEE[(4)]
Birth	number of newborns per million inhabitants by district	INE
Prescription	number of per capita prescriptions in district i	DGS[(5)]
Doctratio	number of inhabitants per doctor (registred in the respective professional order)	DGS

Notes:

(1) INE – Instituto Nacional de Estatística (www.ine.pt).

(2) Gabinete de Estatística e Planeamento da Educação – GEPE (www.gepe.min-edu.pt).

(3) This data is available on *Quadros de Pessoal* at *Direção Geral de Estudos, Estatística e Planeamento* – MTSS (http://www.gepe.mtss.gov.pt). Accessed 3 December 2010.

(4) This data is available at *Direção Geral de Geologia e Energia* – DGE (www.dgge.pt). Accessed 19 February 2011.

(5) This data is available at *Direcção Geral de Saúde* – DGS (www.dgs.pt). Accessed 16 December 2010.

Chapter 6

Explaining the Interrelations between Health, Education and Standards of Living in Portugal. A Simultaneous Equation Approach*

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6.1 Introduction

After the seventies the Portuguese economy has registered the most significant reduction of infant mortality rate among the OECD countries. This indicator – that measures deaths per 1000 live births in the first year of life – has fallen from 55 in 1970 to 3.3 in 2008, being at present one of the lowest rates among the OECD countries (OECD, 2011). Together with the decrease of perinatal mortality rates, the significant reduction of infant mortality is a key factor to understand the increase in life expectancy at birth of the Portuguese population[95]. According to the OECD (2011) data, from 1970 to 2009 life expectancy has risen 12.8 years (from 66.7 to 79.5 years), representing the highest gain among the European Union (EU) countries. Considering that life expectancy is one of the most commonly used indicators to express the health status of the population, we can assert that the Portuguese population has achieved the most significant gain in health status improvements during this period.

Although recognizing that these important health outcomes cannot be dissociated from the investment and strategies adopted in the health sector – in great part linked to the creation of the National Healthcare System (NHS) in 1979 – there are other relevant factors worth mentioning. In fact, in the past decades two main events have contributed significantly to the socioeconomic changes in Portugal: the end of the dictatorial regime in 1974 and the accession to the EU in 1986. Along with health, the Portuguese governments have assumed education as a priority and these two factors have contributed decisively to the improvements of the standards of living. In this context, we can assume that improvements in health and education are strongly related with a higher economic performance in this country through a cumulative causation mechanism with expanding properties. There should be a strong link with reciprocal tendencies between health, education and economic growth that explains the improvement in economic performance in Portugal, based on cumulative causation characteristics that turn the growth process self-expanding. Increasing returns to scale generated in the health and education sector (at least in the long-run) can be a stimulus to economic growth compensating for the decreasing returns of physical capital. As the endogenous growth theory states, a healthy human capital is the engine of economic

[95] See Figures 6.1 and 6.2 in the Annex 6.A.

growth with externality effects spread-out over the whole economy improving labor productivity and thus growth.

Having these potential cumulative causation characteristics in mind, in this chapter we aim to analyze the linkages between health, education and economic performance in Portugal. While there is a vast literature exploring the reverse causality between these three dimensions (Adams *et al*., 2003; Albert and Davia, 2007; Bloom and Canning, 2008, among others), the studies that highlight empirical evidence are scarce and, to our knowledge, there is no empirical studies focusing on the Portuguese economy. By using a simultaneous equation approach we attempt to provide empirical evidence for Portugal, highlighting and disentangling the bidirectional effects between education, health and economic growth through a simultaneous equation approach. In line with Gregory's *et al*. (1972) model, we propose a model that consists on the simultaneous estimation of three main equations: *(i)* the health equation using infant mortality rate as the health status proxy; *(ii)* the human capital equation using the secondary enrolment rate as proxy for the education attainment; *(iii)* a standard augmented Solow-Swan growth model as a proxy of standards of living. Using annual time series data from 1972 to 2009, we estimate the model by 2*sls* and 3*sls* to efficiently evaluate the feed-back and endogeneity effects between the core variables.

To do so, we structure the chapter as follows: In the next section we briefly analyze historical achievements on health, education and growth performance in Portugal along the period considered. In section 6.3 we present the model specification, the data used and explain the estimation methodology. In section 6.4 we discuss the empirical results. The final section summarizes the main conclusions of the chapter.

6.2 Historical trends on health, education and economic performance in Portugal.

Since the seventies a significant effort has been made to improve the health standards of the Portuguese population. These improvements include the increase in life expectancy, the reduction in infant and perinatal mortality rates, the decrease in mortality rates for specific causes and reduction of potential years of life lost, among others. All these health achievements are well documented[96] in national and international statistics, showing a clear convergence of wellbeing indicators in relation to the average of OECD countries.

This remarkable progress in the health status was due, in a great part, to the creation of the National Health System (NHS) in 1979 that assured the universality and equity in the access to health care services. As Campos (2008) notes, "more and better health infrastructures as well as more and better qualified human resources disseminated all over the country, after the creation of the NHS, were responsible for a strong equity effect on the utilization of health care services and for an improvement on their quality".

These improvements on the health sector have necessarily implied very strong investments in several dimensions, such as infrastructures, health equipment and human resources. These investments made possible the generalized access to public healthcare services well illustrated by the evolution of several indicators: number of consultations, acute care beds or average length of stay. The number of qualified human resources had also an impressive evolution during the period under analysis expressed by a notable increase of the number of practicing physicians and nurses per million habitants (0.99 and 1.69 in 1972 to 3.8 and 5.6 in 2009, respectively)[97]. These investments corresponded, along the period under analysis, to a raise of the total per capita expenditure on health from 47US$ (measured in US$ purchasing power parity) in 1972 to 2508US$ in 2008, with public expenditure having a significant role (28US$ in 1970 and 1632.6 US$ in 2008, respectively)[98].

This priority on the health sector is also well reflected by the ratio of total expenditure on health in relation to GDP: in 1972 health spending was 3.2% of GDP

[96] See, for instance, Barros and Simões (2007).

[97] The evolution of these (and other) indicators is available on *OECD Health Data* (several years).

[98] The source was OECD (2011).

against 10.1% in 2008[99]. In fact, the successive increase in health spending is a challenge that policymakers have to deal with in the future. Although this problem is common to other OECD countries, the lower growth rate of the Portuguese economy during the last decade justifies an increasing concern to control public finances and to assure the sustainability of the social system. Nevertheless, it is worth mentioning that (as shown in Figure 6.3 in the Annex) the annual average growth rate in health expenditure per capita in real terms during the past decade was 1.5% in Portugal, clearly below the 4.0% average growth rate in the OECD countries for the same period. On the other hand, in 2009 the share of private expenditure on GDP was already 3.5% in Portugal, well above the 2.7% OECD average (see Figure 6.4 in the Annex 6.A). Taking into account the high income and health inequalities[100] that characterize the Portuguese economy, any health reform should emphasize the efficiency gains. As Campos (2008) highlights, the main challenge that health sector has to face is to control in a more efficient way the expenditures in this sector.

In spite of the importance of all the efforts and investments made in the health sector, health outcomes are also the result of other factors that simultaneously have contributed to an important improvement of the population living conditions. Among these factors, we can highlight the investment in basic infrastructures, like sanitation and access to potable water, better nutrition and house conditions and, above all, the generalization of the access to education.

In fact, it was only after a democratic regime took place in 1974 that education was really assumed by the policy makers as a priority. Significant improvements in the education sector were made, being direct and indirectly linked to health outcomes. As evidence shows, countries with high literacy levels tend to have low infant mortality. Moreover, it is important to note that the magnitude of health inequalities can be reduced by improving educational opportunities (Mackenbach *et al.*, 2008; Rosa Dias, 2009; Cutler and Lleras-Muney, 2010)). On the other hand, as Albert and Davia (2007) refer, since schooling is a causal determinant of occupation and income, the effects of education on health may also reflect its impact on the socioeconomic status.

The concern with education by the Portuguese governments was evident after the seventies: low standards of living, high levels of illiteracy and a huge out-flow of

[99] The source was OECD (2011). See also Figure 6.3 in the Annex 6.A.

[100] Well documented by the WHO (2010).

migration were very restrictive factors to economic development that could not respond to the increasing challenges of a higher integration. Compulsory school first increased from six to nine years and in 2008 it was extended to 12 years. At the same time, the educational system was extended to include pre-primary instruction. Important reforms were also introduced in the secondary and tertiary education system in order to improve the educational standards in Portugal. Under the period of our analysis it was in the secondary education system that the highest enrolment rates' happened. In what concerns the tertiary education system there was a very significant increase of degrees' supply from both public and private institutions, mainly after the eighties. The access to tertiary education was extended all over the Portuguese districts, with polytechnic institutions having a major role in this geographical distribution[101].

Given that secondary schooling was not generalized among a large part of the working age population, other educational strategies were adopted more recently to reintegrate this population into both the secondary and higher education levels[102]. This is at the same time a response to the increasing need of a more qualified human capital able to assimilate the new technologies. As a consequence, there was a strong demand for secondary education that contributed to increase the gross enrolment ratio[103]. However, despite the progress that was made for a free access in the schooling system, the abandoning rate in the Portuguese educational system is of great concern not enabling to achieve higher educational levels.

In spite of all the efforts made in this sector, well reflected by the share of education expenditure on GDP[104], more qualitative achievements in this area are somehow disappointing when compared with other countries' results. According to the 2009 PISA report (OECD, 2010a), in the year 2000 the Portuguese students were among the ones with the lowest reading performance in the PISA's assessment. However, PISA's 2009 results evidence a turning point in the Portuguese educational performance. According to this report, Portugal was the second country with the most

[101] For a detailed review and relevant statistics on the Portuguese educational system in the last 50 years, see GEPE (2010).

[102] "New Opportunities" and "Over 23" (respectively) are two main examples of those measures.

[103] The gross enrolment ratio (GER) provides a measure of the capacity of education systems. It is the ratio of total enrolment, irrespective of age, to the targeted population (UNESCO, 2011).

[104] This share was 5.2% of GDP in 2008 (see Figure 6.5 in the Annex 6.A).

important progress in sciences and the fourth in reading and mathematics standards, cited for the first time close to the OECD average. This is a very relevant progress, especially if we take into account the low socioeconomic background of a great part of the schooling population.

The evolution of the educational and health sectors is clearly a conditioning factor of the country's economic performance, mainly through the role human capital plays to enhance growth. St. Aubyn (2002) analyzes the efficiency of the Portuguese health and education sectors, providing evidence that can help to explain the contribution that these sectors have had on economic performance in the last decades. In what concerns the health sector, the author points out the existence of some important inefficiencies, meaning that the same expenditure level could result in a better health, or, alternatively, the same health status could be achieved by spending less resources. The same study also refers that the scarcity of some resources – general practitioners, nurses or hospital beds – and their asymmetrically distribution in geographical terms may contribute to reduce the efficiency in health care. Concerning education, the analysis must distinguish the quantitative from the qualitative aspects. There has been a very significant investment in education that has allowed enrolment rates and school expectancy to rise, attaining the average levels of the OECD countries. Nevertheless, as the author refers, when a more qualitative approach is used the education performance in Portugal becomes much lower. These qualitative comparisons can be done both at the "stock" level, when adults are considered, and at the "formation" level, when student performance is assessed and compared internationally. Comparisons in two international assessments[105] showed that the Portuguese students were amongst the worst in every category.

Some studies that present empirical evidence on the impact of human capital on the Portuguese economic performance in the last decades, include Freitas (2002) or Teixeira and Fortuna (2003). Freitas (2002) analyzes the evolution of economic growth in Portugal for the period 1960-2000, showing that this development was not uniform during this period. However, considering the whole period, the faster economic growth allowed the country to converge significantly to the standards of living of the OECD countries, with per capita income rising from 41.5% of the EU15 average in 1960 to

[105] The author uses the Third International Mathematics and Science Study (1994-95) and PISA 2000 results in his study.

73.8% in 2000[106]. Freitas (2000) also points out the importance of educational attainment (measured by average years of schooling relative to four European countries[107]) on the convergence process, noting that, after an expressive recovery in the 60's and the 70's, the more recent evolution is less satisfactory.

Teixeira and Fortuna (2003) in an empirical study that covers the period 1960-2001, using VAR and cointegration methods, confirm the important role of human capital on the Portuguese economic performance, highlighting the critical indirect effects of human capital through innovation.

In a recent study based on the cumulative causation principle that covers the period 1965-2006, Antunes and Soukiazis (2011) showed that after a fast recovery of the Portuguese economy relatively to the EU partners and the OECD countries, with economic growth rates exceeding the UE and OECD averages (with an exception for the 1983-1985 period), the Portuguese economic performance has slowdown since 2002, diverging from those countries. According to the authors, the decline of growth after that period can be explained, in a great part, to the low productivity and the loss of competitiveness in external markets.

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[106] Author's calculations based on growth accounting methods.

[107] The four countries are Spain, Greece, Ireland and Portugal.

6.3 The structural model

Literature review

It is argued in this chapter that there may exist a mutual causation tendency between income, health and human capital with feed-back and spillover effects that can give rise to a cumulative causation process, with health improvements leading to higher human capital accumulation and thus to a higher economic growth. As already explained in Chapter 3, the whole process can be described by a virtuous circle with self-expanding tendencies where increasing returns to scales are at work stemming from the health and education sectors. Health has direct effects on human capital and economic growth due to better education and higher productive efficiency. On the other hand, better education contributes to improve health conditions. In what concerns economic growth, as countries improve their economic performance they have the capacity to invest more on education and health services.

While there is a vast macroeconomic literature that investigates the several mechanisms that link health, education and growth/income[108], only few of the empirical studies use system equations to account for those interactions. According to Fingleton (2000), there are some difficulties associated with simultaneous equation modeling that can explain, at least partly, the lack of studies using this methodology. A major problem consists in deciding which variables should be treated as exogenous and which should be treated as endogenous. Another problem is to correctly specify a structural model that is coherent both from a theoretical and empirical point of view. Our study aims to fill this gap and provide consistent empirical evidence considering Portugal as a case study.

One pioneer work in this area is due to Gregory *et al.* (1972) that developed a multi-equation model to explain birth rates in the United States. Assuming that fertility decisions depend on several socioeconomic factors[109], the authors considered four equations that describe the structural model: (i) a birth rate equation; (ii) a permanent

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[108] See, for instance, Howitt (2005) or Bloom (2006).

[109] Those factors are per capita income, education, female labour participation, unemployment rate and the share of non-white population.

income equation[110]; (iii) an infant mortality equation and (iv) an equation for the female labour participation. Using time series data for the period 1910-1968 and 2*sls* and 3*sls* estimation methods the authors' reported results highlighting the large negative impact of education both on infant mortality and on birth rate; a positive impact of income and a negative influence of the female participation on labour market on the birth rate. It is important to note that, in this study, although recognizing this is a critical issue, the authors opted to consider education as an exogenous variable in the fertility, permanent income and infant mortality equations. The reason to this choice is that they assume that education is essentially a policy variable controlled by the government[111].

Other more recent studies include Fielding and Torres (2005; 2005a). Fielding and Torres (2005) analyze the determinants of the cross-country variation in the level of development by modeling four dimensions – the level of material prosperity[112], educational attainment, fertility and health – simultaneously. This approach allows identifying quantitatively the impact that each of these dimensions of human development potentially has on the others. Using data from the World Bank based on household survey for 48 countries, their empirical results show that the effects of fertility rates on the other indicators of development have the expected sign and are statistically significant, although the overall magnitude is relatively small. A more interesting finding of this study is that even small improvements in health outcomes have a large impact on wealth and education. This result emphasizes the idea that, taking into account the effects that health has on the other dimensions of life, investing in basic health is crucial for promoting growth and development. In a different work, Fielding and Torres (2005a), proposed a simultaneous equation model to describe the development process. They considered four main dimensions of economic development – per capita income, education, health and inequality – to be estimated simultaneously. Using the literacy rate as a proxy for education, years of life expectancy as a measure of

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[110] Instead of per capita income, the authors estimate a per capita permanent income equation because they consider that family's fertility decisions depend more on its average income over a period of time rather than on its current income.

[111] However, this view is very restrictive since, as fertility declines, parents are more able to concentrate resources in fewer children, increasing the probability of investing more in their education and health.

[112] Their measure of wealth is based on a household survey recording each household's possessions, so it isn't a measure at the personal level but at the household's level. This approach also permits to avoid references to purchasing power parities (PPP).

health and the Gini coefficient for inequality, the authors apply 3sls to cross-country data for 95 countries. Their empirical results show that there is a correlation between reductions in inequality and improvements in the economic variables mentioned above.

Model specification

Our model specification inspires from Gregory's *et al*. (1972) approach, assuming three equations to estimate simultaneously: *(i)* the infant mortality rate (IMR) equation as a proxy for health, *(ii)* the secondary school real enrolment rate equation as a proxy for education, and *(iii)* the per capita income growth equation reflecting the standards of living of the Portuguese population. The three equations will be estimated simultaneously to capture the interdependence and feedback effects between health, education and income, the core variables of the model.

The infant mortality equation is specified as follows[113]:

$$\ln(IMR)_t = a_1 + a_2 gy_t + a_3 \ln(HSpend)_{t-1} + a_4 \ln(Nurses)_t + a_5 \ln(Fert)_t + a_6 \ln(Edu)_t + \varepsilon_t \tag{6.1}$$

In this equation we assume that the main determinants of infant mortality rate (IMR) are: economic factors expressed by the annual growth rate of per capita income (gy_t)[114]; the financial and human resources devoted to health care, approximated by the per capita health spending ($HSpend$) lagged one period[115], and the number of nurses per million habitants ($Nurses$), respectively; the fertility rate (*Fert*) and education level (*Edu*) (measured by the real enrolment rates on secondary school) are additional socioeconomic factors that are believed to explain infant mortality rate, too.

We expect that economic growth ensuring better standards of living has a negative impact on IMR, corroborating with existing evidence, such as Preston (1975) or Pritchett and Summers (1996). Per capita health spending and nurses reflect monetary

[113] All variable sources and definitions used in our model are given in Table 6.3 of Annex 6.A.

[114] Gregory *et al*. (1972) used permanent income rather than per capita income. Although this criterion may be more pertinent in the IMR analysis, the lack of data enable us to use this variable in our study.

[115] The lagged value of per capita health spending is justified by the fact that previous spending on health assures mother´s health thus reducing infant mortality.

and human investment in health expecting to reduce IMR, too. We assume that nurses, more than practicing physicians, play a critical role delivering health care services to mothers and children, mainly during pregnancy and in the first months of life[116]. In what concerns fertility rate, economic literature emphasizes that, as parents expect their children to live longer they have fewer children and invest more on them, providing more education and health care services (Soares, 2005). Having this in mind, we expect a positive relation between fertility rate and IMR. At last, we also consider the level of education as a determinant factor of IMR. There are many studies that link gains in education with improvements of child health[117]. This may be explained by a greater consciousness (mainly by parents) of the advantages of adopting healthier behaviors, like hygienic habits or better nutrition.

In the health equation (6.1), the right hand side variables, education and growth of per capita income are assumed as endogenous and cannot be estimated by the usual OLS method, since the estimates would be biased and inconsistent. One of the simple ways to deal with the endogeneity problem of the regressors is to use instrumental variables but in this case we ignore the feedback effects of the endogenous variables and the inter-linkages between them. In order to capture the cumulative causation effects between health, education and income a system of simultaneous equations can be used defining the determinants of the endogenous variables.

Therefore, the second equation of the system is education defined as:

$$\ln(Edu)_t = b_1 + b_2 gy_t + b_3 \ln(EduSpend)_{t-1} + b_4 \ln(RatioS/T)_t + \varepsilon_t \qquad (6.2)$$

The dependent variable in this equation (which appears as an endogenous regressor in equation (6.1)) is the secondary school real enrolment rate that depends on economic conditions like the annual growth rate of per capita income (gy_t); financial and human resources devoted to education, proxied by the education expenditure share on GDP ($EduSpend$) lagged one period[118], and the ratio between the students in the secondary

[116] See Younger (2001) and Younger and Ssewanyana (2007) that used similar specifications of the infant mortality regressions on a macroeconomic perspective.

[117] See, for instance, Masuy-Stroobant (2001).

[118] The same argument as in the infant mortality equation can be used here, that previous spending on education will improve current enrolment rates.

school and the number of teachers working in secondary schools[119] (*RatioS/T*). All these factors are expected to influence positively the rate of schooling with the exception of *RatioS/T* that should be inversely related to secondary school real enrolment rate.

The use of real enrolment rates as a proxy for education in our study is explained mainly by the fact that this variable was available for a longer period of time. On the other hand, the choice of the "secondary school" is due to the fact of its pertinence relative to other school levels. In fact, several studies, such as Psacharopoulos and Patrinos (2002) or UNESCO (2011), are consensual in pointing out that the social returns of investing in this education level are more significant than in higher education regardless of the income level of the country. At the same time, secondary school has a crucial role in assuring the linkage to higher education and in preparing many students that go directly to the labour market. However, we should have in mind that it only represents current flows of education. As Teixeira and Fortuna (2003) note, the accumulation of these flows is an element of human capital stock that will be available in the future.

An important factor related with education is income. Secondary school was not compulsory until recently (2008), and in spite of public expenditure having a major role in financing it, there are also important costs supported by families (including transport costs, material expenses, parallel education costs, etc.) that can be seen as extra expenses for parents. This is particularly true when there are strong social inequalities[120] as in Portugal. Having this in mind, instead of income (or permanent income) we rather use per capita income growth reflecting improvements in standards of living in a dynamic sense. Public spending on education and human resources (teachers) employed in the education system is also important for improving educational standards.

In the education equation (6.2) (and also in the health equation (6.1)) the growth of per capita income is an endogenous regressor and therefore this variable has to be specified individually defining its main determinants.

Therefore the third equation of our model is a growth equation of the Solow-Swan type extended to include health and human capital which are endogenous to the system:

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[119] This variable includes teachers that teach to one class team at least and/or do support educational activities in full or partial time.

[120] Data on inequalities (Gini coefficient) was not available for a large number of years, which didn'allow its consideration in our regression analysis.

$$gy_t = c_1 + c_2 \ln(y)_{t-1} + c_3 \ln(Employ)_t + c_4 \ln(K)_t + c_5 \ln(Edu)_t + c_6 \ln(IMR)_t + \varepsilon_t \tag{6.3}$$

In this equation, (gy_t) is the annual growth rate of per capita income at time *t*; y_{t-1}, is the initial per capita income lagged one period[121]; *Employ* is the employed population (in millions) at time *t*; *K* denotes the investment share on GDP as a proxy for physical capital accumulation; *Edu* is the real secondary schooling enrolment rate, and *IMR* the infant mortality rate as defined before.

Equation (6.3) is the well-known growth equation which gives evidence on conditional convergence associated with the endogenous growth theory. Convergence will depend on the distance of per capita income from its steady-state value, the higher this distance the higher the growth will be. According to the endogenous growth theory, there are increasing returns to scale stemming from human capital and innovation that compensate the decreasing returns of physical capital. The growth process will depend on these structural factors which are endogenous to the economic system. Having these qualifications in mind we expect that employment, physical capital and human capital (education) will have a positive impact on growth, while infant mortality (as a proxy for health status) will have a negative influence on growth.

Estimation Methodology and data analysis

We estimate equations (6.1), (6.2) and (6.3) by using 3sls assuming that health status (infant mortality rate), education (real rate of secondary enrolment) and income per capita are simultaneously determined in the system. This method of estimation controls for the endogeneity problem of the regressors, and takes into account the reverse causality between the core endogenous variables of the system. It also considers the error correlation between the equations constituting the system. Therefore it is the most appropriate method to capture the cumulative causation characteristics that turn the system self-sustained.

[121] The relation between the growth of per capita income and its initial level is known as the convergence hypothesis with $c_2<0$ (see Barro and Sala-i-Martin, 1992).

The estimation approach covers the period 1972-2009 of the Portuguese economy. One important issue on time series analysis refers to the order of integration of the variables, where the existence of a unit root is a matter of concern as time – T – increases. So, prior to the estimation of the model, we have to check the order of integration of the variables. Performing the augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP)[122] tests indicate that some of the variables (expressed in logarithms) used in the three equation system are nonstationary. However, in what concerns the IMR and Education variables the tests were in the limit of not rejecting of the null hypothesis[123]. Therefore, we have to be careful in the interpretation of these tests, since one main criticism to Dickey-Fuller and Phillips-Perron tests is that the power of the tests is low if the process is stationary but with a root close to the non-stationary boundary (which is often the case in economic time series). On the other hand, if the series has one or more structural breaks – also a common problem – one might erroneously conclude that the series is non-stationary, while it is stationary with structural breaks[124].

[122] These tests consider in the null hypothesis that the variable contains a unit root, and the alternative is that the variable was generated by a stationary process. While Phillips - Perron test uses Newey-West standard errors to account for serial correlation, the augmented Dickey-Fuller test uses additional lags of the first-difference variable.

[123] Performing the same tests to the variables in log-differences – an usual procedure in time series – confirmed that these transformed variables are stationary and so we can conclude that all variables are integrated of order I(1). Therefore we can say that the variables can be cointegrated – which means that a linear combination of two or more nonstationary variables is stationary (Jones, 1995) – and in this case the model estimation in levels is valid. However, the number of cointegration vectors is unknown which makes difficult to identify a valid linear combination. Yet, if we consider an alternative specification of the model expressing the variables in their first differences we solve the potential problem of non-stationarity of the variables.

[124] On this issue, see McCullum (1993).

Given the power limitations of the tests in these specific circumstances and taking into account the time period under analysis (1972-2009), we opted to report the estimation results of the model presented above, with the variables expressed in logarithms[125].

When we apply 3sls to the system we also need to test the validity of the instrumental variables. The Sargan statistic is used to verify the validity of instruments and the null hypothesis - that the instruments are valid, uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation. However, since in the 2sls regressions we had to correct the three equations for heteroskedasticity and first order error autocorrelation we report the relevant Hansen's J statistic [126].

Table 6.1 explains the set of variables used in the regressions and reports some elementary descriptive statistics. Some of the variables are used as external instruments in the regressions but they do not appear as regressors (i.e. *consultations*). Analyzing these simple descriptive statistics allows us to have an idea of the sharp differences most variables show between the years 1972 and 2009, since minimum and maximum values correspond in most cases to the beginning or end of the period[127].

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[125] We also estimated the model using the variables in log-differences. Nevertheless the results were not satisfactory in terms of statistical significance of the estimates. Despite this, our empirical results from the three equation model expressed with the variables in growth rates showed that education plays an important role explaining the Portuguese income growth and, in turn, income growth is one important factor of infant mortality rate.

[126] To correct for heteroskedasticity and first error autocorrelation the options *bw(auto)* and *robust* were used in stata version 11. With these options Sargan's statistic becomes Hansen's J statistic, which is consistent in the presence of heteroskedasticity and (for HAC-consistent estimation) autocorrelation. For more details on these testes, see Baum *et al*. (2007).

[127] The opposite is true for the variables IMR_t, K_t and $Fert_t$.

Table 6.1 – Descriptive statistics of the variables, 1972-2009

Variables		Obs	Mean	Std. Deviation	Min	Max
Endogenous	IMR_t	38	15.20	12.18	3.30	44.80
	Edu_t	38	34.48	22.69	4.35	68.10
	gy_t	38	0.024	0.034	-0.086	0.106
Exogenous	y_{t-1}	38	10679.22	3613.23	6226.9	15521.8
	$Employ_t$	36	4516.2	497.62	3694	5197.8
	K_t	38	25.78	4.00	15.51	32.47
	$Nurses_t$	36	3.04	0.89	1.69	5.11
	$Fert_t$	38	1.81	0.50	1.32	2.85
	$HSpend_{t-1}$	38	306.52	315.58	0.3	906
	$EduSpend_{t-1}$	38	3.78	1.12	1.30	5.20
	RatioS/Tt	38	13.9	4.06	8.75	24.31
Instrumental	$Consultations_t$	38	3.30	0.46	2.40	4.30

It is interesting to see the figures on secondary education and infant mortality (Figure 6.6, Figure 6.7 and Figure 6.8 in the Annex 6.A) showing the remarkable improvement that has been made in these sectors.

6.4 Empirical results

The three equation health-education-income model is estimated by 3sls and the regression results are shown in Table 6.2. As we explained before this method of estimation captures the important linkages and feed-back effects between health, education and income growth that generate cumulative causation tendencies leading to higher economic growth.

Table 6.2 – 3sls and 2sls regression results of the health-education-income system. Portugal 1972-2009

3sls

Equations	Explanatory variables						R^2	F-stat	p-value
	gy_t	$\ln HSpend_{t-1}$	$\ln Nurses_t$	$\ln Edu_t$	$\ln Fert_t$	Constant			
$\ln IMR_t$	0.3494	0.0054	-1.7915***	-0.2527***	0.6020***	4.7896***	0.993	1043	0.000
	(0.829)	(0.224)	(-15.365)	(-5.034)	(2.841)	(17.219)			
	gy_t	$\ln EduSpend_{t-1}$	$\ln RatioS/T_t$	Constant					
$\ln Edu_t$	-0.5532	0.7827***	-2.0265***	7.4998***			0.928	153.2	0.000
	(-0.381)	(3.276)	(-6.543)	(7.064)					
	$\ln y_{t-1}$	$\ln Employ_t$	$\ln K_t$	$\ln Edu_t$	$\ln IMR_t$	Constant			
gy_t	-0.4553***	0.3401***	0.1863***	0.0453***	-0.0488**	0.7430	0.769	27.06	0.000
	(-9.168)	(4.936)	(9.647)	(3.580)	(-2.609)	(1.067)			

2sls

Equations	Explanatory variables						R^2	AR(1) test[(1)]
	gy_t	$\ln HSpend_{t-1}$	$\ln Nurses_t$	$\ln Edu_t$	$\ln Fert_t$	Constant		
$\ln IMR_t$	0.3441	-0.0012	-1.8196***	-0.2573***	0.4699**	4.9514***	0.994	χ^2_2=2.586
	(0.758)	(-0.054)	(-13.809)	(-4.478)	(2.358)	(20.232)		p-value=0.2744
	gy_t	$\ln EduSpend_{t-1}$	$\ln RatioS/T_t$	Constant				
$\ln Edu_t$	-2.5730**	1.1650**	-1.5464**	5.8378**			0.921	χ^2_3=2.787
	(-2.298)	(2.184)	(-2.090)	(2.316)				p-value= 0.4256
	$\ln y_{t-1}$	$\ln Employ_t$	$\ln K_t$	$\ln Edu_t$	$\ln IMR_t$	Constant		
gy_t	-0.4265***	0.3228***	0.1779***	0.0617***	-0.0261*	0.5412	0.790	χ^2_5=2.820
	(-8.379)	(5.211)	(12.633)	(3.059)	(-1.776)	(0.822)		p-value=0.7277

Notes:

(1) The use of "robust" option gives Hansen statistic test rather than the Sargan statistic; Estimates are efficient for arbitrary heteroskedasticity and autocorrelation and statistics are robust to heteroskedasticity and autocorrelation.

Endogenous variables: gy_t, $\ln IMR_t$, $\ln Edu_t$

Exogenous variables: $\ln y_{t-1}$, $\ln Employ_t$, $\ln K_t$, $\ln HSpend_{t-1}$, $\ln Nurses_t$, $\ln Fert_t$, $\ln EduSpend_{t-1}$, $\ln RatioS/T_t$, $\ln Consultations_t$. ***** p<0.01, ** p<0.05, * p<0.1**

The obtained results are generally quite satisfactory in terms of the goodness of fit and statistical significance of the coefficients. A more detailed analysis of each equation shows that most coefficients present the expected sign and are statistically significant with some exceptions.

Having a closer look at each individual equation, health (infant mortality) is mostly explained by human resources devoted to this sector (number of nurses), the education level and fertility rate. These variables are highly significant at the 1% significance level. These results collaborate with previous findings in the literature that the higher human resources employed in the health sector and the higher the level of education the lower the infant mortality will be. The impact of human resources is the one with the higher magnitude and this result corroborates with existing evidence on the role nurses usually have in health care services related to child care in the first year of life. A 1% increase in the number of nurses is responsible for 1.79% decrease in IMR (all other things being constant). If we consider that low rate of infant mortality creates a new more healthy generation then investing more in human resources in the health and education sectors is the right policy for improving standards of living. The fertility rate is also in line with early findings influencing positively the infant mortality. Our results predict that a 1% decrease in fertility rate induces 0.6% decrease in IMR. As we explained before, this result is justified by the fact that high fertility will force parents to devote less economic resources to health and education, increasing therefore infant mortality. Parents having fewer children can invest more in their health. On the other hand, it is more likely that infant mortality will increase when the fertility rate is high since there will be a higher number of new born children. Therefore it is a matter of a scale measurement. We also find that the education level has a negative impact on IMR. It is shown that every 1% increase in education level is responsible for 0.25% decline in IMR.

In the health equation it was not possible to find any significant impact of the growth of per capita income or the per capita spending on health sector (lagged one period) on infant mortality. This can be taken as evidence that what matters more in the health sector are factors related to education and human resources than financial spending which does not take into account its efficiency dimension.

In the education equation the most significant impact comes from per capita spending on education and the students/teacher ratio. Our empirical results show that (the lagged) per capita education expenditure (*EduSpend*) has a positive impact on the secondary school real enrolment rate with statistical significance at the 1% level with elasticity equal to 0.78%. This is an expected result since more spending on education will create better conditions in schooling increasing therefore the attendance rate. Another variable with a significant negative impact on education at the 1% level is the students/teacher ratio. It is shown that when the S/T ratio increases by 1% education declines by 2.02%, therefore the relation is negatively elastic. This is also expectable since a lower ratio means more human resources in the education system that may improve the teaching quality strengthening the participation level. It is also important to note the teachers' role beyond the classroom, supporting other students' activities. Nevertheless, the growth of per capita income has not a significant effect on schooling attendance. These results reinforce the idea that public support on education is a key factor to educational frequency at this level of basic schooling.

In the growth equation all variables have a significant impact and carry the expected sign. The negative impact of the lagged per capita income is in line with the conditional convergence hypothesis of the endogenous growth theory. In what concerns the other factors explaining economic growth, our empirical results highlight that capital investment, employment and education improvements are of extreme importance in the growth performance of Portugal, being all statistically significant at the 1% level and having their expected positive impact on growth, with elasticity 0.32%, 0.18% and 0.06%, respectively. In what respects infant mortality, it evidences a negative and significant impact on growth at the 5% level. It is shown that a 1% decrease in IMR is responsible for a 0.05% increase in per capita income growth rate. These are important results reflecting that capital accumulation and employment are beneficial to growth and that education (although in a quantitative perspective) is in fact one of the driving forces of economic growth, supporting the endogenous growth theory. They also evidence that better health conditions (due to the reduction in infant mortality) endorse economic growth.

Moreover, looking at the whole model we can say that the main link between health and economic growth works through education.

6.5 Chapter concluding remarks

The main argument of this chapter was that there should be a cumulative causation mechanism that explains the interdependence and feed-back effects between health, education and economic growth. To capture these important linkages a simultaneous equation approach was used defining the main determinants of the core endogenous variables of the system. The health-education-income system was estimated by 3sls, in order to provide consistent estimates and handle the problem of the endogeneity of regressors. This method also considers cross-equation error correlation capturing important links between the core endogenous variables. The results found fill the gap of the lack of empirical evidence on this topic and particularly focusing on an individual country, Portugal.

Regarding the health equation it is shown that human resources and education standards are important determinants explaining the remarkable progress in reducing infant mortality rate in Portugal. Fertility rate also has a significant impact on infant mortality collaborating with the idea that lower fertility allows parents to invest more on children´s health and education. Therefore, human resources and socioeconomic factors explain mostly the progress that has been made in Portugal to improve health standards.

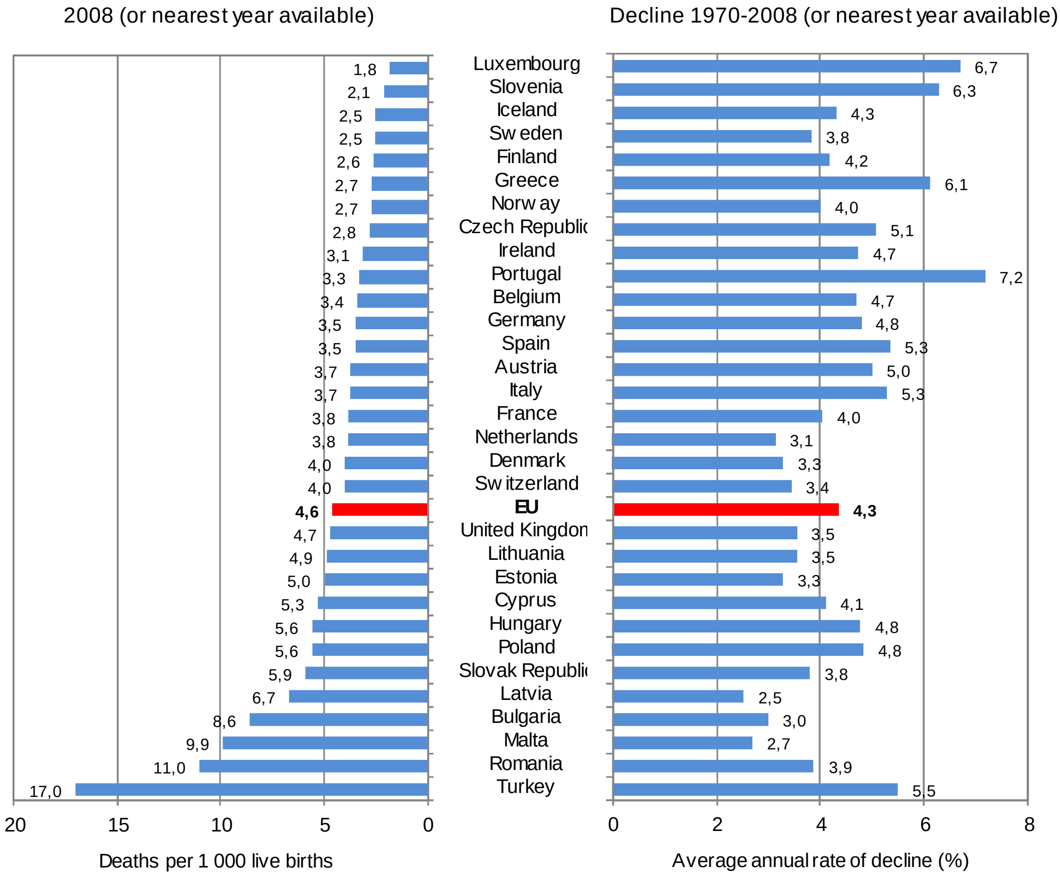
With respect to education equation, again human resources (students/teachers ratio) and per capita spending on education are the most important factors explaining the progress that has been made in the schooling enrolment. These results reinforce the idea that public support on education is an important incentive to improve the education standards.

Physical capital accumulation, employment and education are important factors in explaining the growth performance in Portugal and this is in line with the endogenous growth theory. Health factors (measured by infant mortality) also play an important role explaining per capita income growth. We also obtain evidence favoring the well-known conditional convergence hypothesis. With respect to this, increasing returns to scales should be at work stemming from human and health capital, compensating the diminishing returns of physical capital.

In general terms our model specification and estimation technique are shown to be useful instruments explaining the important inter-linkages between health, education and economic growth in Portugal, inducing a cumulative causation growth process with expanding tendencies.

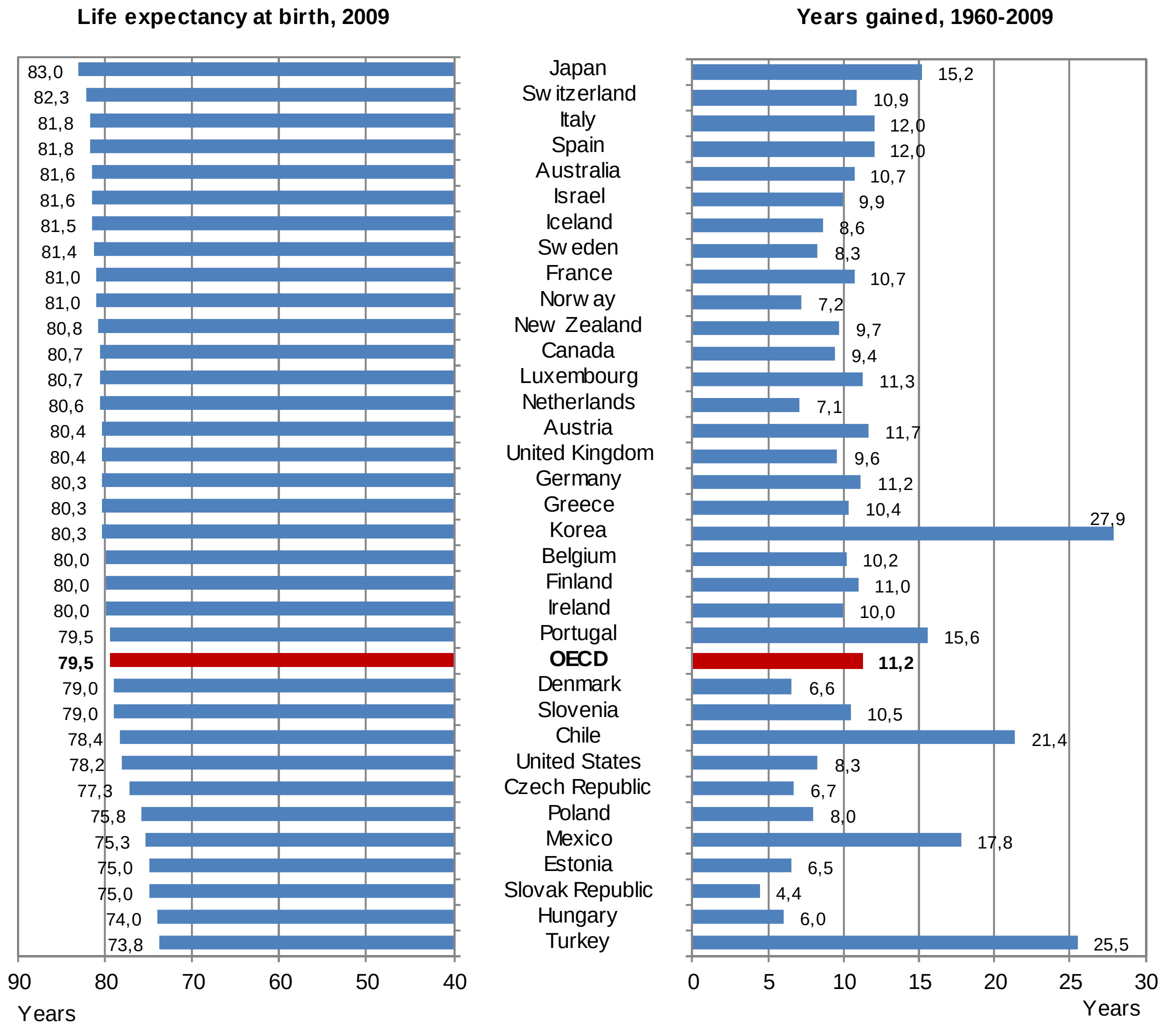
Annex 6.A.

Figure 6.1 – Infant mortality rates, 2008 and decline 1970-2008



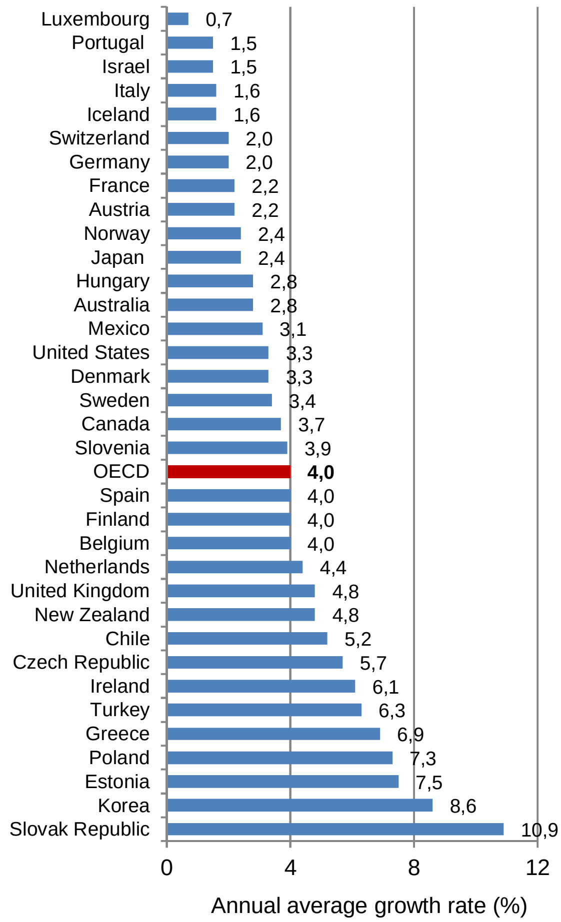
Source: OECD (2010a).

Figure 6.2 – Life expectancy at birth, 2009 (or nearest year), and years gained since 1960



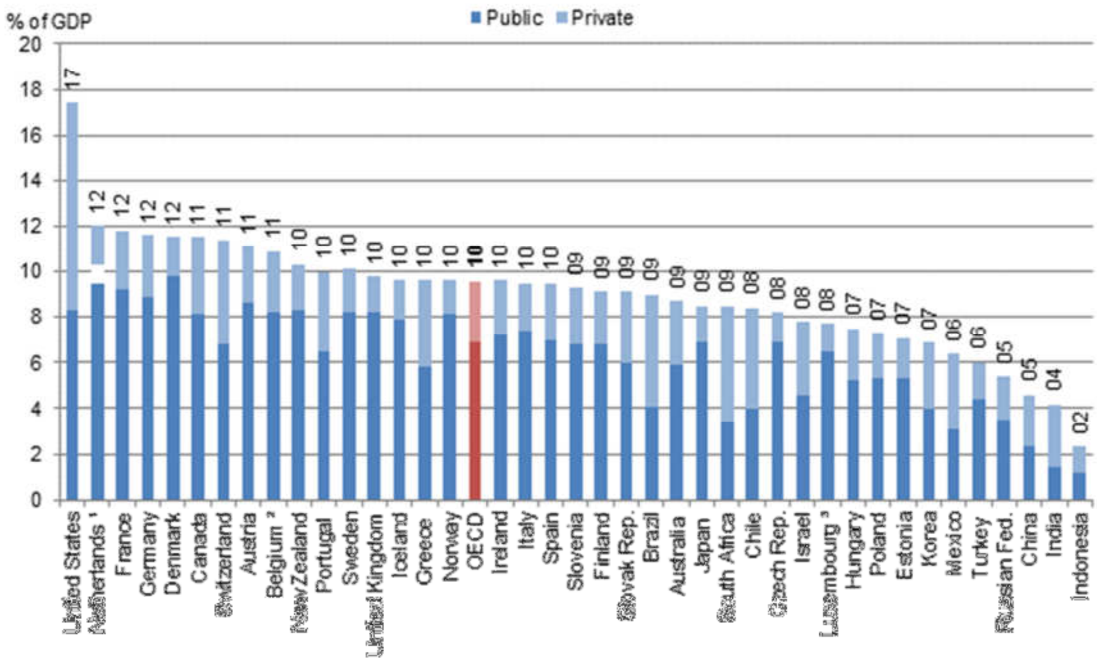
Source: OECD (2011).

Figure 6.3 – Annual average growth rate in health expenditure per capita in real terms, 2000-09 (or nearest year)



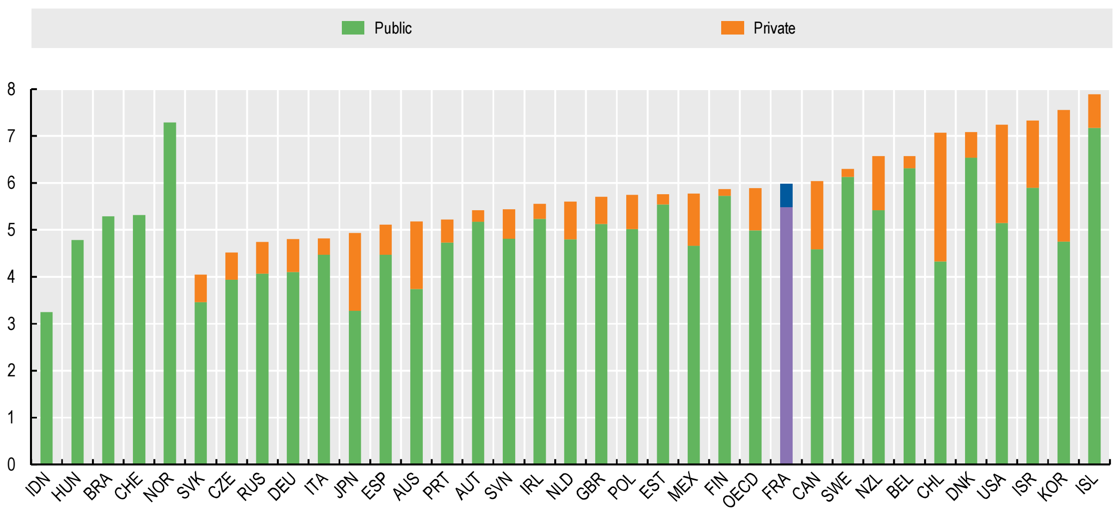
Source: OECD (2011a).

Figure 6.4 – Total health expenditure as a share of GDP, 2009 (or nearest year)



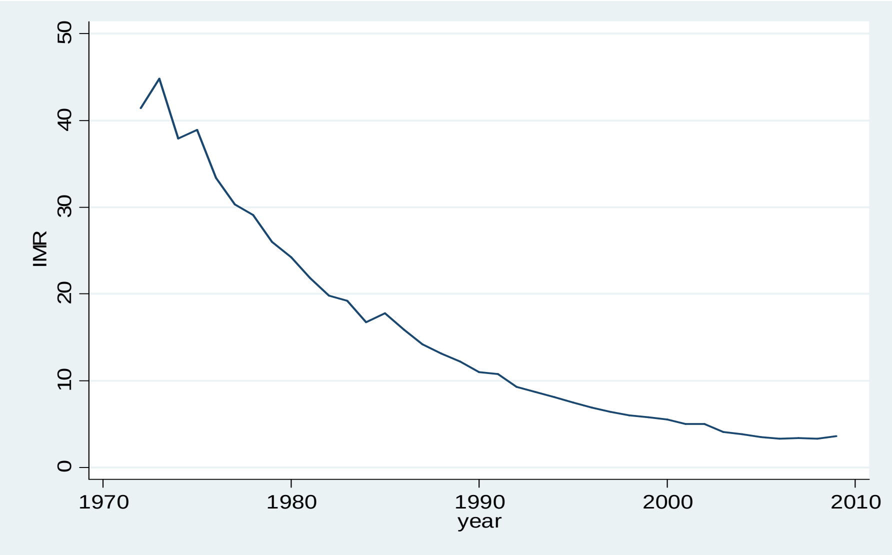
Source: OECD (2011a).

Figure 6.5 – Public and private expenditure on education for all levels of education (as a percentage of GDP, 2008 or latest available year)



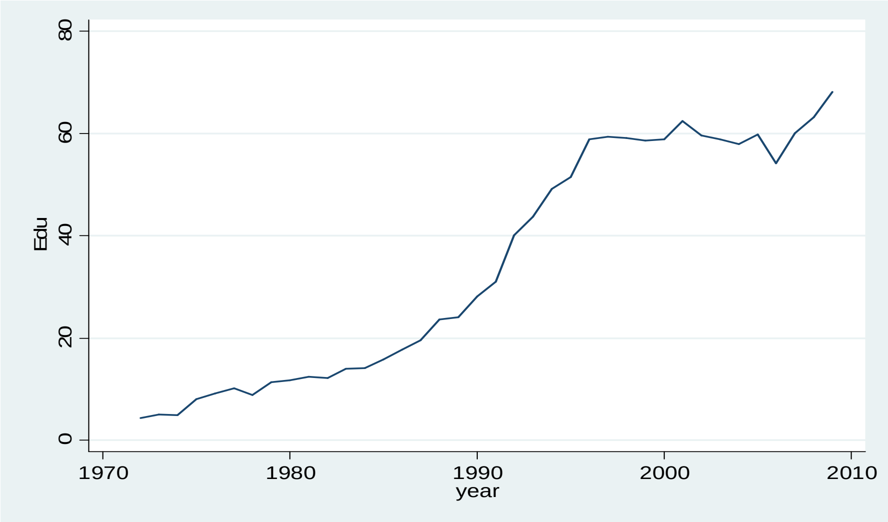
Source: OECD (2011b).

Figure 6.6 – Infant mortality rate, Portugal, 1972-2009



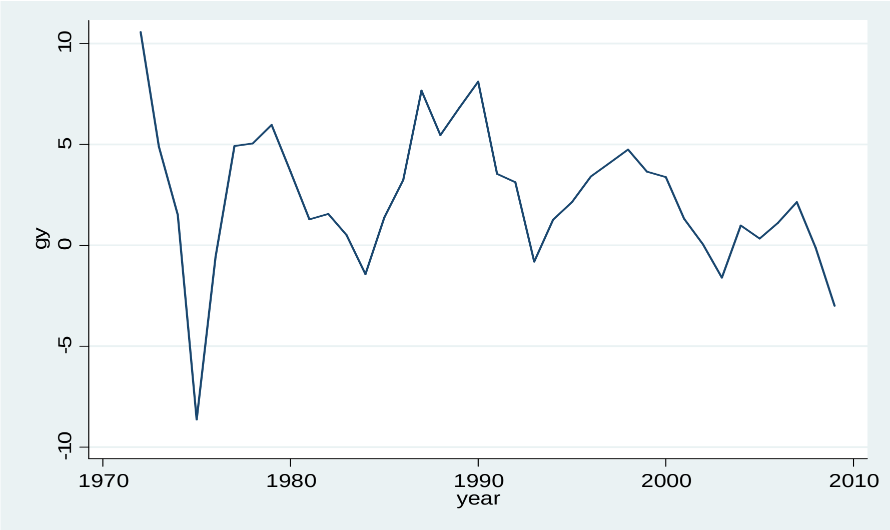
Source: OECD (2011).

Figure 6.7 – Real secondary school enrolment rate, Portugal, 1972-2009



Source: GEPE (2009); Pordata (2011).

Figure 6.8 – Annual growth rate of per capita income, Portugal, 1972-2009



Source: Pordata (2011).

Table 6.3 – Description of the variables and data source

Variables	Description	Source
IMR	Infant mortality rate: deaths per 1 000 live births	OECD Health data[(1)]
Edu	Real secondary school enrolment rate	GEPE[(2)]; Pordata [(3)]
y	Real GDP per capita in 2006 constant prices	Pordata
Employ	Employed population (in millions)	Pordata
K	Investment share on GDP	PWT 7.0[(4)]
Nurses	Practising nurses, density per 1 000 population	OECD Health data
Hspend	Total public expenditure on health (per capita)	Pordata
$Fert_t$	Fertility rate: number of children that would be born to each woman at the end of her childbearing years if the likelihood of her giving birth to children at each age was the currently prevailing age-specific fertility rates	OECD Factbook 2008[(5)]; OECD Country statistical profiles[(6)]
EduSpend	Total public expenditure on education (as a percentage of GPD)	Pordata
RatioS/T	Number of students per teatcher on secondary schools	Pordata
Consultations	Number of contacts with an ambulatory care physician divided by the population	OECD Health data

Notes:

(1) OECD. OECD Health Data (several years), http://www.oecd.org/health/healthdata

(2) Gabinete de Estatística e Planeamento da Educação - GEPE (2009), http://www.gepe.min-edu.pt/np4/376.html.

(3) Pordata. www.pordata.pt. Accessed 5 January 2012.

(4) Heston, A.; Summers. R.; Aten, B. (2011), Penn World Table 7.0 (PWT 7.0), http://pwt.econ.upenn.edu/. Accessed 3 January 2012.

(5) OECD Factbook 2008: Economic, Environmental and Social Statistics.

(6) OECD. Stat Extracts, Country statistical profiles, http://stats.oecd.org/. Accessed 11 January 2012.

Final Conclusions

In this dissertation we have focused our study on the importance of health factors on economic growth which has become a central question in the economic and political debate in most developed and developing countries. This increasing interest is directly associated with the emergence of two main trends. One is the ageing of the population which results in the decrease of the proportion of working age population, a phenomenon that several authors named as “the accounting effect of demographic change” (Bloom *et al*., 2010; Prettner *et al*., 2010). The other trend, also related to this demographic evolution and with the epidemiology transition, is the increasing incidence of chronic diseases. These diseases affect not only the elderly population but also the working age population and they represent a burden on health expenditure. On the other hand they represent a serious restriction to achieving further gains in life expectancy. On the contrary, they make it possible to have simultaneously economic growth and life expectancy decline (Ruhm, 2000; Gertdtham and Ruhm, 2002).

With this dissertation our main aim was to highlight the impact of some of these tendencies on economic growth of the OECD countries. In a context of being important constraints on economic growth (especially in the European countries) and imposing increasing pressure to adopt cost reduction policies (including in the health sector), we consider that empirical evidence on the impact of health factors on economic performance are crucial for policy recommendation. Having in mind that the inclusion of health factors in the growth analysis implies additional difficulties, namely at the empirical level, in this dissertation we attempt to provide evidence derived from methodologies that are more appropriate to deal with the complex interrelations between health, education and economic growth.

The core idea of this dissertation is to analyze the linkages between health, human capital and economic growth explaining the mechanism through which these three dimensions act in order to generate higher living standards. This mechanism is based on reciprocal interactions that generate a cumulative causation process of higher growth with expanding tendencies due to increasing returns of scales steaming mainly from the health and education sectors. Our empirical evidence supports this mechanism especially in the case of Portugal.

Having all these proposals in mind, this study was structured in a way to provide empirical evidence that shows the importance of health status on economic growth in conjunction with human capital qualifications assuming that the interaction of both favor the pace of economic growth.

In Chapter 1 we presented a small introduction explaining the motivations, methodology and organization of this study trying to make clear its objectives and how to deal with them.

The literature review is explained in Chapter 2 focusing mainly on two theoretical streams, the neo-classical and endogenous growth models. We begin by explaining the human capital concept and how it has been developed in the economic growth literature. Having in mind the complex interactions between health, education and economic growth, in this chapter we also explored the channels through which health can affect growth and we presented two alternative approaches to measure the impact of health on the economy; the extended Solow Swan model (known as the Mankiw, Romer and Weil (1992) model) and the Howitt's (2005) model (as an illustration of the endogenous growth models). At the same time, the explanation of the two approaches allowed us to highlight some advantages of the extended Solow Swan model (namely its simplicity), which justifies the preference for this approach in the subsequent chapters (Chapters 3 and 5). Nevertheless, it is important to note that the simultaneous equation approach developed in Chapter 6, by taking into account the cumulative characteristics between health, education and income growth, captures in a great part the feedback effects between these dimensions predicted by Howitt's (2005) model.

In Chapter 3 our aim was to analyze the impact of health conditions on economic growth, using a growth regression framework. We focused our attention on a sample of 22 OECD countries which has the advantage of having more reliable available data. Since this group of countries has high education levels, we were particularly interested in establishing the main links between education and health and how these two dimensions are crucial to enhance growth in the OECD countries. In the empirical analysis we have used relevant proxies for health and education that better characterize this group of countries. In what concerns health, we aimed to bring evidence on three different dimensions – the health status of the population, the health care service and health care resources – being able at the same time to describe some important tendencies of the OECD health systems. As a proxy for education the patents ratio was used, which is more adequate to capture higher levels of human capital reflected in the innovation and research activities. Having in mind the problem of the endogeneity of the regressors, we implemented a panel data dynamic framework and GMM estimation methods for the period 1980-2004. Our findings suggested that cerebrovascular mortality rate, average length of stay, number of physicians and acute care beds were the most significant health factors affecting the standards of living of the developed countries. These results are in line with those reported by Suhrcke and Urban (2006), reinforcing the idea that analysing the impact of health on economic growth needs to go beyond the use of the most common conventional factors. Nevertheless our estimation results failed to evidence a statistical significant impact of the education factor when proxied by patents, in order to capture higher level of human capital qualifications.

In Chapter 4 our main aim was to analyze the determinants of life expectancy reflecting the health status of the population of the OECD countries using data for the period 1980-2004. Since developed countries face an important challenge with the ageing of their population, a relevant issue is to deal with the determinants of the elderly population. Therefore, we considered along with life expectancy at birth (total population, males and females) also the determinants of life expectancy at 65 years old for males and females. In spite of the existence of a large amount of studies in this area, only few overcome the endogeneity problem between income, health and education or the existence of unobserved heterogeneity. In this study we estimated a production function for health of the OECD countries, for the period 1980-2004, using a panel data framework that allows for the endogeneity problem between income and education. In this perspective, we had to instrument these explanatory variables to obtain unbiased and consistent estimates in the regressions. Using as a first criterion the statistical significance of the correlations between the endogenous variables and possible explanatory variables, we performed statistical tests that confirmed that total expenditure on health (per capita), number of medical graduates per density of practicing physicians (per 1000) and the patents ratio (per 1000) assuming to capture higher levels of human capital were valid instruments.

In this empirical study we used different proxies for health care resources than those that have been used in similar studies covering OECD countries (such as health spending, number of physicians, hospital beds). We opted to consider the number of consultations (per capita) as a good measure of an effective use of the available human resources represented by the physicians. In this way, the health production function uses the health care resources (measured by consultations), socio-economic factors (per capita income and education) and lifestyles (tobacco and alcohol consumption) as inputs and life expectancy (at different ages, total population and according to gender) as output.

In what concerns life expectancy at birth, our empirical results confirmed that all explanatory factors considered in the analysis do have the expected effect and they are statistically significant. However, when we applied the same analysis by gender we obtained different results. While for women the main determinants of life expectancy were education and consultations; for men, income, alcohol and tobacco was shown to be the most significant explanatory factors of life expectancy.

In what concerns the analysis of life expectancy at age 65, data was only available by gender. The obtained results reinforced the idea that education and consultations were the most important determinants of life expectancy for women, while per capita income and alcohol consumption were the main factors explaining life expectancy for men. However, lack of data does not allowed us to consider in our estimations the cumulative effects of individuals' lifestyles (tobacco and alcohol consumption) on their life expectancy, so we should look to these results with some caution. Nevertheless, our empirical evidence, while different from that obtained by Joumard *et al.* (2008), help to understand the differences that still exist between males and females' life expectancy.

In Chapter 5 our main aim was to provide a similar analysis of that of Chapter 3 but at a regional level for the Portuguese economy. With this study we intended to provide additional evidence on the determinants of regional growth in Portugal during the period 1996-2006 testing the importance of health factors on this process. In this way our analysis was an effort to fill an existing gap in the literature on regional growth that considers a broader notion of human capital.

Our empirical evidence showed that demographic and health factors play a critical role on regional growth at a district level. As expected the ageing of the population, expressed by the proportion of population with age 65 and over and by the dependency ratio, has a significant negative impact on regional growth and this impact will be stronger in the long run. In what concerns health factors, our empirical results showed that the availability of doctors and per capita prescriptions has a significant and negative impact on regional growth. These results reflect that a higher ratio of inhabitants relative to doctors imply more difficulties in accessing health care services, which is still a characteristic of the Portuguese NHS, reported recently by the WHO (2010), while per capita prescriptions may evidence a poor health status of the population.

In this chapter we also intended to highlight the dimension of demographic and socioeconomic disparities between *littoral* and *interior* districts. When we differentiate our analysis according to these two geographical areas we found that there are distinct driving forces explaining their economic performance. As expected, our results showed that the energy consumption (as a proxy for physical capital), the birth rate and employment were the factors with higher explanatory power in the interior districts having a positive impact on regional growth. Per capita prescriptions (as proxy for the health status of population) have a negative impact on growth. In what concerns the *littoral* districts, we found evidence that energy consumption (with a positive impact), the proportion of the elderly (over age 65) and per capita prescriptions (with negative impacts) were the major determinants of regional growth.

We consider that the significant and negative impact of prescriptions should be a matter of some concern. It is well known that the Portuguese population shows higher levels of medical consumption when compared with other European countries and this behavior has important consequences on the economy through the increasing burden of public spending on medication (OECD, 2009a). On the other hand, assuming that this variable captures a poor health status of the population, we may expect that this result also reflects a loss of human potential at a regional level.

At the same time, our empirical analysis at a regional level for the Portuguese economy highlights the urgent need to narrow the asymmetries between *littoral* and *interior* areas. This is a necessary condition for a sustainable growth and for the improvement of the wellbeing and social inclusion of the whole population. To reverse the ‘depressing’ tendency that characterizes the *interior* districts in general, it is important to implement strategies that attract labour and investment to these regions. In fact, as our study shows, the development of these districts depends on the crucial role played by physical investment, employment and the birth rate.

In Chapter 6 our main aim was to disentangle the complex interactions between health, education and income through a simultaneous equation approach, in line with the model proposed by Gregory *et al*. (1972). We believe that modeling in this way the interaction between health, human capital and income it is a manner to capture the cumulative causation characteristics that turn the growth process self expanding. In order to provide consistent estimates and to overcome the endogeneity problem of the regressors we estimated the three equations of the system by using 3sls.

Our estimates show that the model used is useful to understand the linkages between health, education and growth and it provides evidence that the main link between them works through education. In what concerns the health equation, our results revealed that the major determinants of infant mortality rate were human resources devoted to health care (measured by nurses) and education. Fertility rate was another important factor, reflecting the association between lower fertility rates and higher investment of parents on children's health and education. In the education equation, the students/teachers ratio and per capita spending on education are shown to be the most important explanatory factors of the schooling enrolment rate. These results provide evidence that public investment on this educational level is of an extreme importance, contributing to a generalized access to secondary education in Portugal. Concerning the per capita income growth equation, we found that infant mortality rate was also an important explanatory factor of the standards of living. Our results showed that during the period under analysis (1972-2009) physical capital accumulation, employment and education were important factors in explaining the growth performance of the Portuguese economy.

In a global perspective, our dissertation corroborates with the idea that health matters not only at an individual level – as already evidenced by many microeconomic studies – but also for the whole economy. Taking into account many features that characterize nowadays the health status of the population, and mainly those of most developed countries, our empirical evidence highlights the significant and positive (negative) effects of a better (poor) health status on economic performance. Better (poor) health means a gain (loss) of human and economic potentialities with important consequences on economic performance.

Our dissertation highlights the important role of the cumulative causation effects between health, education and economic growth. Education plays in fact a crucial role in developing individual's psychosocial competencies and contributes to having more favorable job and income opportunities. In a context of increasing prevalence of chronic diseases, directly related with unhealthy lifestyles and so in a great part avoidable, any health-prevention or cost-control strategies to be successful must consider simultaneously the two dimensions – health and education. On the other hand, health status is also a key factor for better educational attainment, allowing to explore better job opportunities and, consequently, having better living conditions. Moreover, better standards of living allow people to invest more in health and education, which in turn will have positive effects on economic growth. This cumulative causation process is important for understanding the inter-linkages between health, education and income able to generate a sustainable growth process with expanding tendencies.

Our dissertation also highlights that there are still important difficulties in what concerns the availability of data at a macroeconomic level conditioning the empirical research. This was particularly true when we wanted to provide a more detailed analysis – according to gender (in Chapter 4) – or at a more disaggregated geographical level – in the case of the Portuguese districts (in Chapter 5).

Our dissertation also points out several interesting lines for future research. It would be interesting, for instance, to investigate the mutual casual links between education, health and economic growth using a multi-equation model like in Chapter 6, with more adequate health proxies rather than the infant mortality used (life expectancy or other index of health status) and extend this analysis to the OECD countries. It should be also desirable to include in the system an explicit equation for labour productivity and measure the impact of health and human capital on it, specifying therefore the cumulative causation process in a more complete way.

In general, we consider that this thesis makes a significant contribution to the growth literature, analyzing the crucial role of health on economic growth and the way that health interacts with human capital and income. Empirical evidence reported in this study support this idea measuring the impact of health achievements on economic growth and disentangling the complex linkages between health, human capital and standards of living.

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