fondazione RODOLFO DEBENEDETTI

f R D B

IX European Conference

Health Expenditures, Longevity and Growth

Brigitte Dormont, Joaquim Oliveira Martins, Florian Pelegrin, Marc Suhrcke

HEALTH EXPENDITURES, LONGEVITY AND GROWTH

by

Brigitte Dormont, *University Paris Dauphine, Legos and University of Lausanne, IEMS*

Joaquim Oliveira Martins, *OECD Economics Department* (*)

Florian Pelgrin, *DEEP University Lausanne-HEC, CIRANO, IEMS*

Marc Suhrcke, *World Health Organization, EOHD* (*)

(revised version May 2007)

To be presented at the **IX European Conference of the Fondazione RODOLFO DEBENEDETTI** *on "Health, Longevity and Productivity"*
Limone sul Garda , 26 May, 2007

(*) The authors would like to thank Pietro Garibaldi for comments on earlier versions of the text. We also thank Christine de la Maisonneuve for useful remarks and inputs. The usual disclaimer applies. **The views expressed are those of the authors and do not reflect those of the OECD, the WHO or its Member countries**.

TABLE OF CONTENTS

HEALTH EXPENDITURES, LONGEVITY AND GROWTH 1

Introduction 4
1. From Ageing to Longevity 5
1.1 The potential labour resources associated with longevity gains 6
2. Ageing, Technological progress and Health expenditure growth 8
2.1 Health care expenditures have increased steadily 8
2.2 The main drivers of health expenditure growth 9
2.2.1 Why ageing is not the main driver of expenditures: the role of proximity of death 9
2.2.2. The predominant impact of changes in medical practices 10
2.3 Technological change and its impact on health status and spending 12
2.3.1 The pattern of innovation and product diffusion in health care 12
2.3.2 Impact of insurance systems and regulatory factors on technological progress 14
2.3.2. The impact of health care on health status 15
2.4 The optimal level of health expenditures 18
2.4.1 The value of health 18
2.4.2 Estimating the optimal health care spending share 20
3. The influence of income growth on health care expenditures 23
3.1 Is Health really a luxury good? 23
3.2 An econometric investigation 24
4. Projecting aggregate health spending 28
4.1 Demographic drivers of expenditure 28
4.2 Non-demographic drivers of expenditure 30
4.3 Projection model for health care expenditures 31
4.4 Expenditure projections for the US, EU-15 and Japan 32
5. What is the impact of health on productivity and growth? 34
5.1 Health, human capital and growth: general results 34
5.2 Does health contribute to growth in rich countries? 36
5.2 Mechanical impact of ageing and individual productivity 40
5.3 R&D, innovation and market structure in the health sector: Europe vs. the US 40
5.3.1 A comparison of medical innovation input and output 41
5.3.2 Market structure characteristics explaining differences in innovative performance 43
6. Summary and policy discussion 44
REFERENCES 47

ANNEX I: SPECIFICATION OF THE UTILITY FUNCTION AND THE INCOME ELASTICITY 60

ANNEX II: DATA SOURCES AND METHODS OF HEALTH EXPENDITURE PROJECTIONS . 62

Estimating death-related costs 62
Calibration of the expenditure curves on the OECD Health database 62
Projecting the demographic effects under a "healthy ageing" scenario 63
The starting point of the projections 63
TABLES & FIGURES 64

Introduction

1. Ageing is expected to create a drag on potential growth in many developed countries, which is unlikely to be compensated by economic factors, such as higher capital intensity, migration or productivity. The economic consequences of a dramatic change in population structure have been abundantly documented and modelled in the literature (e.g. Auerbach and Kotlikoff (1987); Ingenue (2001); and Börsch-Supan *et al.* 2002, 2006) These papers have shown that, unless bold policy action is taken to reform pension systems and to improve the functioning of labour markets, social security systems are on an unsustainable path. The focus of this literature has been to address the impact of the decrease in fertility rates from post-World War II levels. An issue to which much less attention has been devoted is how to take advantage of increase in *longevity without incapacity*.

2. Increased longevity without incapacity should not be perceived as a negative shock (contrary to ageing). It is good news both for individuals and the economy providing that additional human resources brought by longevity are not lost by a premature departure from active life. In this regard, several studies (*e.g.* Duval, 2003; OECD, 2005; Börsch-Supan, *et al.*, 2005) have shown that the decision of early retirement is much less a matter of individual choice than the result of perverse incentives created by current institutional arrangements in pension systems and labour markets. If longevity translates into *healthy ageing* and better health status of workers near retirement, this may lead to growth potential, especially in European economies. The impact of ageing on the economy could then depend critically on the creation and political support of mechanisms linking the duration of active lives to longevity gains (see Oliveira Martins *et al*., 2005; Galasso, 2006).

3. In this context, there are many arguments to believe that health matters for growth and productivity but also economic outcomes matter for health. Different mechanisms have been stressed in the health literature to explain such relationships. Among others, healthier individuals could reasonably be assumed to produce more per hour worked. Second, health may also impact labour supply. Moreover, health also influences the decision to supply labour through its impact on wages, preferences and expected life horizon. Third, according to human capital theory, better health contributes to more educated people and thus more productive people. An increasing life expectancy will also encourage people to acquire more education. Fourth, the state of health of an individual (or the total population) is likely to impact not only upon the level of income but also the distribution of this income between savings and consumption and hence the willingness to undertake investment, which in turn promotes growth. Fifth, R&D in health, which represents a substantial share of total R&D, may contribute as an engine of growth.

4. Against this background, this paper tackles these issues by offering an integrated view of the relationships between, health spending, medical innovation and adoption, health status, growth and welfare.[1] The different links are illustrated in the Diagram 1. Health spending is

1 . Noteworthy, the paper focus on aggregate health care spending (both public and private), leaving aside questions on old-age dependency and long-term care that are somewhat of a

supposed to trigger technological progress. Technological progress is a potential source of better outcomes in terms of longevity and quality of life, a direct source of growth for the bio-tech industries and an indirect source of growth through an improvement of human capital. The latter contributes to GDP per capita through two main channels: an effect on participation of the population in the labour force and labour productivity levels. In turn, income growth has an impact on expenditure growth, as richer countries spend a higher share of their income on health. Moreover, preferences for longer lives stimulate demand for technological innovations.

[Diagram 1. Links between Health spending, Technological progress, Longevity and the GDP

5. A key question concerns prospects and sustainability of health expenditure growth. Micro and macroeconomic analyses have shown that the impact of ageing is relatively small. In contrast, the role of preferences is crucial in the growing share of health spending to GDP. We provide empirical evidence that health expenditures tend to grow in line with incomes. On the top of this income effect, it is the diffusion of new medical practices that explains most of the drift of health expenditures per capita. Given these determinants of health expenditures, we carried out several projection exercises showing a potential substantial increase in expenditure shares by 2050. We discuss why evidence that health and health spending play a positive role in aggregate growth is rather mixed in rich countries, but highlight the strong potential for health R&D and innovation as a source of GDP growth.

6. The structure of the paper is as follows. The first section will focus on demographic facts, disentangling the role of longevity and carrying out some 'thought experiments' on the indexation of active life on longevity. Section 2 will focus on health care expenditures, technology and health status from a micro-level perspective. Section 3 investigates empirically the relation between GDP growth and health expenditures. Section 4 develops a projection method to assess the size of aggregate expenditures that could be channelled to the health sector. In section 5 we will attempt to assess the impact of these expenditures on potential growth and productivity. The final section will summarise and draw some policy conclusions.

1. From Ageing to Longevity

7. Ageing trends are the result of two different and contrasted phenomena: the change from a high to a low fertility regime and the increase in longevity. The baby boom and subsequent bust are massive but *transitory* shocks. In contrast, the smooth but steady increase in longevity does look like a *permanent* shock (Oeppen and Vaupel, 2002; EC, 2003; Barbi, 2003). Supporting the hypothesis of a permanent shock, the frontier of longevity in different countries has increased almost linearly by 2.4 years per decade over the past century and a half (Figure 1.1). A similar trend was observed on average for the United States, Europe and Japan over the past 40 years (Table 1.1), though with a wide cross-country dispersion.

---

different nature. Data and empirical evidence focus on three main developed regions: the US, EU (mostly EU-15) and Japan.

[Figure 1.1 Historical trends in female life expectancy, 1840-2000]
[Table 1.1 Increases in life expectancy for different age groups]

8. During the XXth century, increased longevity has resulted from uneven developments of mortality rates across age groups. The first half of century mainly experienced a reduction in child mortality. In the second half, the reductions in mortality were located in prime and old age groups. The role of health care was also different in the two periods (Vaupel, 2002; Yashin, 2003; Lichtenberg, 2003). The development of mass vaccination and antibiotics, together with improved hygiene and life style, help eradicating infectious diseases (tuberculosis, pneumonia, flu, etc.). The latter were the main cause of mortality in early XXth century, affecting in particular young children. But since then, the reductions in mortality have been associated with distinct factors, notably the treatment of cardiovascular diseases and cancer. These diseases are prevalent mainly at older ages and their treatment has triggered the development of medical innovation, as will be discussed below.

9. Against this background, most national population projections[2] embody a significant slowdown in longevity gains for the period 2005-2050 that is hard to justify with the current state of knowledge. On average for EU-15, the national projections assume gains in life expectancy longevity at birth of only 1.2 years per decade over the next fifty years (Table 1.2). This implies a significant deceleration of longevity. A stronger decline applies for Japan, whereas the projected slowdown is less marked in the United States (where longevity gains have also been lower).

[Table 1.2 Comparison of past with projected gains in life expectancy]

10. Accordingly, Oeppen and Vaupel (2002) argued that current population projections need to be adjusted for higher longevity gains. In addition, Cheung and Robine (2007) provided empirical evidence on a shift of the modal age of death in Japan, suggesting that currently there is no evidence that we are approaching an upper limit in human longevity. Olshansky *et al.* (2005) have put forward an opposite view. They noted that extrapolation of past trends cannot provide a good basis for projections, because the longevity gains are driven by improvements in environmental, economic and social factors that may not last in the future. In particular, widespread obesity trends in many developed countries would contribute to a deterioration of the health status of the population which *in fine* will reduce life expectancy. While being agnostic on whether longevity gains could continue or not, the consequences of longevity scenarios embodied in national projections (cf. Table 1.2) can be tested.

1.1 The potential labour resources associated with longevity gains

11. The OECD economies have experienced during the past decades a relative abundance of labour resources. Due to the baby-boom, labour force has increased steadily since the early 1970s. But the situation will change radically over the next decades. Following the projections of Burniaux *et al.* (2003), at unchanged labour market and immigration conditions, the labour force

2 . For a discussion on the underlying parameters of national demographic projections (2005-2050) see Oliveira Martins *et al.* (2005).

could decline in the EU-15 by around 25 million workers by 2050 (or -14%) compared to the peak to be reached by 2010 (Figure 1.2). In Japan, the labour force has already started this decline and is projected to fall by 22 million workers (-36%) by 2050 compared with 1995. Only in the United States, labour force is projected to continue increasing, by around 37 million workers (+26%) between 2005 and 2050.

[Figure 1.2 Simulations of the effect of ageing and longevity on the labour force]

12. The decline in European labour force is mainly due to the strong reduction in the number of prime-age (aged 30-49) and young workers (aged 15-29), while the number of old workers (50-64) in Europe will increase by around 5% (Figure 1.2). In Japan, all age groups decline markedly. The sustained decline in total labour force could induce a substantial drag on potential growth, which could reach 1% in Japan and 0.8% per year in Germany (cf. Oliveira Martins *et al*, 2005). At unchanged conditions, it is unlikely that increased capital deepening and/or total factor productivity could fully compensate for this shock.

13. To investigate the contribution of longevity to counteract these worrying trends, we carried out two 'thought experiments'. First, we shifted the observed participation ratios[3] by age group over time in line with the average increase in life expectancy. In a second experiment, we shifted over time the old-age threshold (usually 65+) usually defining working age population (15-64 years) also in line with longevity gains.

14. It can be seen that some compensation can be found for the declining numbers of young and prime-age workers in the labour force. The gains are limited in Europe due to low participation in the labour force of older workers (Figure 1.2). When the same simulations are carried out for the working-age population, the gains are substantially larger, leading to a near stabilisation of the European labour force over the period 2005-2050 (Figure 1.3). Therefore the potential is not negligible.

[Figure 1.3 Simulations of the effect of ageing and longevity on the working-age population]

15. Using these counterfactual scenarios for labour force and working-age population, we also computed alternative scenarios for old-age dependency ratios. This 'longevity indexation' appears to be sufficient to stabilise, or even reverse, the upward trends in dependency ratios defined over the working-age population. The effect is stronger in the United States and EU-15 than in Japan, where the ageing process is particularly strong. In contrast, when considering the ratios over labour force projections, the effect of the longevity indexation is powerful in the United States and in Japan, but becomes much weaker for EU-15 (Figure 1.4). This is due to the much lower labour market participation ratios of older workers in Europe. The effect of indexation is therefore conditioned by the functioning of labour markets, indicating a strong complementarity between the two types of policies.

3 . Note that the baseline projections of Burniaux *et al.* (2003) assumed unchanged policies and thus the participation ratios of older workers were also assumed to remain constant over time.

[Figure 1.4 Simulations of the impact of longevity indexation on dependency ratios]

16. These simple back-of-the-envelope calculations suggest that an appropriate management of longevity gains could be used to compensate for the ageing of populations in labour markets, as well as to old-age dependency ratios that are a key parameter for the sustainability of pension systems. The potential could be even larger if past longevity trends are maintained, contrary to what is generally assumed in population projections.

17. The critical condition for these longevity gains to materialise in longer working lives is a certain dynamic equilibrium between the increase in life expectancy and the number of years in good health (the so-called "healthy ageing" regime). Achieving this virtuous cycle, may require large investments in health care, which to be sustainable may require in turn a careful design of insurance mechanisms and use of technological progress. Understanding these mechanisms is the aim of the next section.

2. Ageing, Technological progress and Health expenditure growth

2.1 Health care expenditures have increased steadily

18. As a share of GDP, total spending on health care[4] has risen steadily for the past 30 years. In particular, public spending grew by some 50% between 1970 and the early 1980s (Figure 2.0). How can we explain this rise of health expenditures as a share of GDP? A first conventional explanation is that changes in transfer programs such as Medicare and Medicaid have tend to increase spending on health. However, this story does not explain why we observe similar changes in Europe. A second explanation is the cost disease story of Baumol (1967, 1993). Health care, like other services, uses labour intensively at the expense of relatively low productivity growth. As a result, this leads to a rising relative price of health care and, depending on preferences, to a rising shares of expenditures. Triplett and Bosworth (2000) provide evidence that labour productivity growth in the health sector was negative between 1987 and 1997. Moreover, the medical care component of the CPI increased faster than the overall CPI. As a third explanation, Newhouse (1992) argued that the bulk of the residual increase is attributable to technological change. This explanation has received increasing attention in the literature (*e.g.* Fuchs, 1986; Okunade and Murthy, 2002; Cutler, 2004, Jones, 2004) and will be discussed in detail below.

[Figure 2.0 Evolution of Total, Public and Private OECD health spending]

19. In the course of the 1980s, governments started to react to these spending trends by putting in place a number of cost-containment policies (see Docteur and Oxley, 2003), resulting in a stabilisation of public health care expenditures in the OECD from mid-1980s to late 1990s. Concomitantly, private health spending accelerated. As public cost-containment policies acted

4 . For data reasons, total spending incorporates both health and long-term care expenditures (LTC). Given the low share of LTC in total spending (on average below 1%), this does not change the qualitative picture for health care.

mainly through macroeconomic mechanisms (*e.g.* wage moderation, price controls or post-postponement of investments), they could not be sustained forever.[5] Thus, after a long period of cost contention, since 2000 the share of public expenditures to GDP is increasing at a rate of over 3% per year for the OECD. In this context, an important question is what are the drivers of these expenditure trends? Can they be related to demographic or other factors? The next section addresses these questions.

2.2 The main drivers of health expenditure growth

20. The combined effects of ageing and the fact that health care expenditures increase with age are often referred to as a major determinant of the future health care expenditures. These two phenomena are illustrated for one country, France, in Figures 2.1 and 2.2 (wider cross-country evidence will be provided in section 4).

[Figure 2.1 Proportion of people aged 65 and over demographic effect, France]
[Figure 2.2 Individual health expenditure by age group (Euros), France]

21. Many projections of future health care expenditures simulate the impact of ageing simply by applying demographic previsions to a static expenditure profile by age. However, the profile of expenditures by age group changes over time. Using again French data (Figure 2.3), a sizeable upward drift can be observed for each age group between 1992 and 2000. Since it concerns individual expenditure by age, this drift is a non-demographic effect related to changes over time in patients' behaviour, physicians' practices, as well as to technological progress. As we will see below, it is not due to a deterioration of patients' health status.

[Figure 2.3 France, health expenditures by age group (euros), 1992 and 2000]

22. Therefore, simply using Figures 2.1 and 2.2 to project health expenditure growth would miss the main part of the story. As we will see below, the upward drift of the expenditure profile displayed in Figure 2.3 is by far the main driver of expenditure growth. Ageing only plays a relatively minor role.

2.2.1 Why ageing is not the main driver of expenditures: the role of proximity of death

23. Estimates on cross-sectional or panel data for OECD countries led to a very small or non significant influence of age on health expenditures, whereas GDP has a sizeable and highly significant impact (Getzen, 1992; Gerdtham *et al.*, 1992, 1998; Hitiris and Posnett, 1992); Leu 1986; O'Connell, 1996; OECD, 1987). A possible explanation was put forward by Zweifel *et al.* (1999), following Lubitz and Riley (1993) who pointed out that yearly payment per person for people dying within the year were 7.1 larger than for survivors (based on US *Medicare* beneficiaries in

5 . Indeed, it is difficult to contain wages and, at the same time, attract young and skilled workers in the health care sector. Controlling prices is not easy when technical progress is permanently creating new products and treatments. Equipments also need to be renovated, especially in presence of rapid technical progress.

1988). Accordingly, health expenditures appear to be increasing with age just because of the high health care costs in the proximity to death, together with the fact that the probability of dying increases with age. Once proximity to death is controlled for, age *per se* would not influence health expenditures. Zweifel *et al.* (1999) used micro-econometric estimates on Swiss data to support this finding. If it is the death proximity, instead of age, that influences expenditures, the increase longevity should then slowdown expenditure growth.

24. Subsequently, other papers investigated the respective influences of time to death and age on health expenditures (Seshamani and Gray, 2004a, 2004b; Stearns and Norton, 2004; Zweifel *et al.* (2004); Werblow *et al.*, 2007)). A very enlightening article written by Yang, Norton and Stearns (2003) makes it possible to understand the mechanisms at stake. The authors conduct a graphical analysis of person-month data relative to 25,994 *Medicare* beneficiaries. Figure 2.4 displays the individual health expenditure in relation to death proximity for three age groups (65 to 74, 75 to 84 and 85 and older). The common characteristic of these curves is the huge increase in health expenditures when around four months before death, from $2,000 twelve months before death, to $8,000 in the last months. Figure 2.5 displays the average health expenditure by age, distinguishing between decedents (people dying in the year) from survivors. Large differences also emerge between the two groups, supporting the role of proximity to death. Interestingly, the curve of survivors' expenditures is still increasing with age, but at a milder pace.

[Figure 2.4: Individual health expenditure ($) in relation to death proximity Medicare beneficiaries (USA)]

[Figure 2.5: Individual health expenditure ($) by age group decedents versus survivors, Medicare beneficiaries (USA)]

25. This empirical evidence suggests that: i) both age and time to death have an influence on health expenditures; and ii) health expenditure projections have to include time to death. These points are by now widely accepted. Using US projected life tables for 2020, Stearns and Norton (2004) show that omitting time to death leads to an overstatement of around 15 % for health expenditures.

2.2.2. The predominant impact of changes in medical practices

26. We turn now to the main driver of expenditure growth, i.e. the upward drift of the age-profile of health expenditure over time related to non-demographic factors. Dormont, Grignon and Huber (2006) have proposed a micro-simulation method for analysing changes over time in the age profile that makes it possible to disentangle changes in morbidity on the one hand, and changes in practices on the other hand. Concerning morbidity, the authors consider a vector of chronic illnesses and disability indicators and allow for the changes over time in their prevalence by age. This enables to compute the resulting impact of all these changes on expenditures by age.

27. Changes in practices for a given morbidity level are captured by changes in the coefficients which measure the influence of morbidity on health care use. Changes in these coefficients show, for each given illness, whether health care expenditure is higher in 2000 than

in 1992. This method makes it possible to encompass the changes in patients' preferences, physicians' behaviour as well as the impact of technological progress.

28. Dormont *et al.* (2006) use a representative sample of 3,441 and 5,003 French individuals, respectively in 1992 and 2000.[6] Their micro-simulation approach identifies the components of the drift observed between 1992 and 2000 in the age profile of health expenditures. To give an illustration, the observed drift in pharmaceutical expenditures is displayed in Figure 2.6. A large upward drift is observed for the age profile of individual expenditure between 1992 and 2000 (profile 1 and 4, respectively). The simulations show that this large upward drift is entirely due to changes in practices for a given level of morbidity (profile 2). For morbidity level they experienced in 1992, individuals have spent more in 2000 than they would had spent in 1990, irrespective of their age. In contrast, the changes in morbidity induce a downward drift (profile 3) for all age groups (except 70+). Put differently, changes in health conditions have retrospectively led to lower spending.

[Figure 2.6: Decomposition of the drift of the age profile of individual expenditures, France (micro-simulations), pharmaceutical expenditures, 1992-2000]

29. Applying the simulated profiles by Dormont *et al.* (2006) to the structure by age of the French population leads to an assessment of the relative effects of demographic change and expenditure profile drifts for the period 1992-2000 at the aggregate level. The results for pharmaceutical and total expenditures are provided in table 2.1. Pharmaceutical expenditure increased by around 67%, of which changes in practices explain 52 percentage points. The rise in health care expenditures due to demographic change appears to be very small (4.6 percentage points). For total expenditures, the changes in practices explain 13 percentage points, compared with 3.4 percentage points due to changes in the age structure. The aggregate effect of changes in morbidity appears to be negative, reflecting the impact of health improvements of individuals for a given age between 1992 and 2000. Noteworthy, these health improvements cancel out the increase in costs related to pure ageing effects.

[Table 2.1 Explaining health expenditure growth, France]

30. What are the changes in medical practices made of? To answer this question, a more detailed account of different expenditure items (*e.g.* physician consultations, pharmaceutical consumption) is provided in the next section.

6 . The database used by Dormont *et al.* (2006) has the advantage of providing detailed information about morbidity making possible to: (i) provide empirical evidence of global health improvement; and, (ii) evaluate the savings due to changes in morbidity..

2.3 Technological change and its impact on health status and spending

2.3.1 The pattern of innovation and product diffusion in health care

31. Health economists have usually identified technological change as the principal culprit for health expenditure growth. Gelijns and Rosenberg (1994) criticise this 'linear conceptualization' of medical progress, where "new ideas" of the biomedical scientists would go from laboratory to animal testing and then to bedside.[7] Actually, the research leading to medical innovation does not necessarily take place in the biomedical sector: lasers, ultrasounds, magnetic resonance imaging, computer, nanotechnology have their origin in more general-purpose research and innovations. Moreover, development does not end with the adoption of an innovation. Adoption is generally the beginning of a long process of redesigning the innovation based on feedbacks from users. These incremental improvements after initial adoption play a crucial role in the development of pharmaceutical drugs and medical devices.

32. In other words, medical technological change entails two basic mechanisms: i) the substitution of old treatments by new ones, this generally induces a gain in efficiency; ii) the extension of new treatments. The substitution effect leads to a gain in productivity and often lower unit costs, in accordance with the standard view of the impact of technological progress. The rising costs in health care spending are mainly due to the treatment expansion effect, *i.e.* related to a potential demand for new goods and services.

33. Available statistics from the TECH network[8] on heart attack treatments enable to make this discussion more concrete. Heart attacks are both the most common cause of death in most developed countries and an area where many innovations have occurred over the past 15 years (see Box 1). This can be seen in the rising number of innovative procedures for heart attack treatments in the US and seven countries participating in TECH (Figures 2.7 and 2.8). Other indicators taken from the OECD Health database (Figures 2.9 to 2.11) also show the increasing use of new medical procedures, such as cataract surgery, hip replacement and knee replacement.

[Figure 2.7: Changes in the surgical treatment of heart attack USA, 1984-1998]
[Figure 2.8: Share of angioplasty procedures involving stents in heart attack admissions. Seven countries 1994-1998]
[Figure 9-11: Use of cataract surgery, hip and knee replacement in OECD countries]

---

7 . Quoting Gelijns and Rosenberg (1994): "… *This appears to contradict conventional wisdom. Outside of medicine, technological change is identified as the primary driving force behind improved productivity and economic growth. One of the most decisive effects of technological change is that it makes it possible to produce a given volume of output with a smaller volume of inputs. Why, then, when considering medicine, is technological change deemed responsible for rising costs?*".

8 . The Technological Change in Health Care (TECH) Research network set up by Mark McClellan and Daniel Kessler has brought together investigators in clinical medicine, economics and epidemiology from sixteen countries to carry out international comparisons of technological change in the treatment of heart attack.

Box 1. Medical innovations in Heart attack treatment

A heart attack is an acute event characterised by the occlusion of the arteries that supply blood to the heart. Together with drug therapy (aspirin, beta blockers, etc.), patients can receive various treatments such as thrombolytic drugs, cardiac catheterization, percutaneous transluminal coronary angioplasty and bypass surgery. Catheterization is a procedure used to view the blood flow to the heart to improve the diagnosis. Developed in the late 1970s, angioplasty appeared more recently than bypass surgery, which was developed in the late 1960s. It is an alternative, less invasive procedure for improving blood flow in a blocked artery by inflating a balloon to create a channel through the blockage. This innovative procedure is less costly and more respectful of patients' quality of life than bypass surgery. Angioplasty can replace bypass surgery in some cases. However, the use of angioplasty is spreading above and beyond this type of substitution. Since the mid-1990s, it has increasingly been performed with the implantation of one or more stents (small mesh tubes that hold open the coronary artery) to improve outcomes.

34. Cutler and McClellan (1996) showed that growth in treatment costs for heart attack in the U.S results entirely from diffusion of innovative procedures, as prices paid for a given level of technology are fairly constant over time. In the US, by 1998, more than half of heart attack patients received catheterization and usually another procedure, instead of only 10 % of heart attack patients in 1984. The diffusion of angioplasty with stent also appears clearly in Figures 2.7 and 2.8.

35. Turning to other areas, the introduction of new medications such as selective serotonin reuptake inhibitors (SSRIs), including Prozac and similar medications changed completely the treatment of depression. In the mid-1980s, treatments with psychotherapy or tricyclic anti-depressors were the norm. Berndt *et al.* (2000), and Cutler and McClellan (2001) show that the introduction of SSRIs was followed by a demand boom in the US. In 1991, 30 % of depressed patients were treated with an SSRI; this proportion rises to nearly half by 1996. Berndt *et al.* (2000) show this substitution effect leading to a gain in efficiency. The spending per incremental remission probability is reduced by about 20 %. Costs have been rising because of treatment expansion: diagnosis and treatments for depression doubled over the 1990s. The latter may have resulted from supply-induced demand encouraged by manufacturers of SSRIs providing incentives to doctors to watch for depression. However, the supply of these new products meets demand needs that were not previously satisfied. Indeed, many studies in the 1980s suggested that half of depressed persons were not appropriately diagnosed and treated.

36. For cataract, the substitution of older technologies led to obvious gains in efficiency (Shapiro *et al.* (2001). There is no increase in the cost of a cataract operation between the late 1960s and the late 1990s, while health outcomes have increased: better visual quality and a reduction in complication rates. As operations are safer and more effective, a larger number of patients are operated (Figure 2.9), including those with a less severe visual acuity problems.

37. This pace of technological progress in health care is likely to have had an impact on the relative prices of health relative to other goods in the economy. Non-adjusted official medical price indices have generally increased more rapidly than prices in the rest of the economy. For example, in the US, medical care-CPI increased by 1.8 percentage points annually above the growth rate of the aggregate CPI between 1960 and 1999 (Cutler and McClellan, 2001). However, when prices are adjusted for quality and variety of products ('true" price indexes) it is possibly

that may have actually declined (see Box 2). If a high price elasticity for health products, this would have induced a shift of demand that more compensated for the substitution effect from less to more cost-efficient technologies.

Box 2. Technical progress and quality/variety adjusted medical prices

A way to measure the benefit of health care is to focus on consumers' utility and consider price effects adjusted for quality and/or variety. When consumer's marginal valuation of the good equals its costs, it is possible to link costs and value using a hedonic analysis (Griliches, 1971). This approach cannot be directly applied to health care, as patients are insured and there is asymmetry of information between patient and care providers. Therefore, to assess the benefit of medical care, direct evidence on the expected value of health improvement. Accordingly, Cutler *et al.* (1998) build a Cost of Living (COL) Index to measure how much consumers would be willing to pay for changes in medical treatments and prices over time (Fisher and Shell, 1972). Applying this method to the price of heart attack treatments, they estimated the Cost of Living Index (COL) relative to the GDP deflator to have actually fallen by about 1 percent annually. This result was subsequently confirmed by Cutler and McClellan (2001) on heart attack, depression and cataract treatments.

Even if quality-adjusted prices do not fall, new technologies may increase the variety of products, which is equivalent to say that the "true" relative price of health care *vis-à-vis* all other goods in the economy decreases. Consider for example the case of a demand for variety model with a CES utility function: $U = \sum_i x_i^{(\sigma-1)/\sigma}$, where σ>1 is the elasticity of substitution among products. To simplify, let us assume price symmetry ($p_i = p$, $\forall i$). The true composite price index is then equal to $P^* = n^{(1-\sigma)} \cdot p$. With two types of composite goods, say health (*H*) and all other goods (*O*), the true relative price would be: $P_H^* / P_O^* = (n_H / n_O)^{(1-\sigma)} \cdot (p_H / p_O)$. Thus, even if the usual price ratio (p_H / p_O) remains constant, the "true" relative price P_H^* / P_O^* would decrease when the pace of product creation in the health sector is much faster than in the rest of the economy.

2.3.2 Impact of insurance systems and regulatory factors on technological progress

38. The incentives to produce the just discussed innovation in the health sector are dominated by insurance systems and public provision. Weisbrod (1991) suggested that expanding insurance has provided an increased incentive of the R&D sector to develop new technologies, as new products tend to be always validated *ex-post* by the insurance system. Certain type of innovations will be favoured, depending on the design of the health insurance and on the payment systems implemented by the payers.

39. The cross national comparisons performed by TECH network, referred above, have shown that there are big differences in patterns of technological change across countries (McClellan and Kessler, 2002). The absolute differences in innovative procedure growth rates between rapid-growth countries (Australia, US, France, Israel) and slow-growth countries (Canada-Ontario, Finland) amount to a factor of two or more over a five-year period.

40. Many countries have a health care system characterized by a monopsonic third party payer, which can control the implementation of new technologies through effective budget

ceilings. In countries having several third party payers, competition among them will tend to drive up technology adoption. Different providers' payment systems also matter: fee-for-services and per-case remuneration schemes are more likely to encourage a higher adoption of new technologies than fixed remuneration schemes (capitation, global budget).

41. In some countries, hospitals have to apply separately for funds for large scale investments. In other, large investments are financed through the general remuneration of the hospitals. Direct control by a single payer through regulation of separate grants for large investments is likely to have a negative influence on the adoption rate of new technologies.

42. Bech *et al.*(2006) show that differences in technology use across countries and in their rates of adoption can be explained by these institutional factors. The main factors, which lead to lower utilization rates, appear to be the monopsonic payer and the funding of investments by specific grants. Baker and Brown (1999) suggest that managed care has slowed the rate of diffusion of new medical technologies. Dormont and Milcent (2006) examined how the diffusion of angioplasty in French public hospitals could not be sustained and ultimately was slowed by the introduction of a global budget constraint.

43. In consequence, improving efficiency and eliminating waste are important goals for regulation but a trade-off can emerge on the speed of adoption of technological progress. Some benchmark of optimal spending needs to be defined in order to determine whether the benefit of new technologies is larger than their additional costs

2.3.2. The impact of health care on health status

44. The most common indicator of health care outcomes is life expectancy at birth. As pointed above, the latter has increased steadily over the XXth century, by about 30 years in the US and in comparable countries. In recent years, EU-15 has performed better than the US in this respect (Figure 2.12), the latter displaying a persistent gap of around 1.5 years by 2004.

[Figure 2.12 Life expectancy at birth in the EU-15 and the US, 1990-2004]

45. Has life in good health (or the health status) also increased over time? Unfortunately, life expectancy fails to take into account morbidity differences. To address this shortcoming, an increasingly used measure is the health-adjusted life expectancy (HALE). The World Health Organisation (WHO) has computed gender-specific HALEs for all countries of the world: the results show a large variability of HALEs between countries, with still an advantage of the EU-15 vis-à-vis the US, at least two years for each gender. However, no data has been produced by the WHO to make it possible to compare HALE over time, and see how the evolution of HALE compares to that of life expectancy.

46. A European project, the European Health Expectancy Monitoring Unit (EHEMU), aimed at constructing comparable indicators on disability-free life expectancy (DFLE)[9] for European countries (Michel and Robine 2004). The results are mixed: while some countries have experienced an increase in lifetime lived free of disability, others have hardly shown any change over the period examined. More precisely, for a given age, mild and severe disability appears to have declined in several European countries, as well as in Japan. In some countries, the gains in DFLE are actually higher than the gains in life expectancy at birth (e.g. France, Germany, Japan).[10] In the US and the U.K., DFLE has increased but at a slower pace. In general, the age of the onset of many chronic diseases has also been decreasing.

47. A study carried out by Robert Fogel (2003) on a large sample of 45,000 US veterans does not give support to the idea that increase in life expectancy led people to spend more years plagued by chronic illnesses. The average age of onset of various common chronic conditions (such as heart disease, arthritis, respiratory disease, etc.) increased by 10 years over an 80-year period, while life expectancy increased by 6.6 years. These results are in line with those of Freedman, Martin and Schoeni (2002).

48. Has health care played a role in reduced mortality and morbidity? Most studies point out several identification problems: many other factors than health care have influenced mortality, including behavioural changes, declines in pollution with the delivery of clean water and the removal of waste, increased education with advice about personal health practice, urbanization, etc. Nevertheless, there is evidence that better health care has improved health status.

49. Cutler, Deaton and Lleras-Muner (2006) showed that since the 1930s, mortality reductions have been driven by health care, first by vaccination and antibiotics, then by the intensive care procedures mostly for cancers and cardiovascular diseases. Similarly, Murphy and Topel (2006) showed that the life expectancy gains of about 9 years in the US between 1950 and 2000 can be attributed to reduced mortality from heart disease and stroke (respectively, + 3.7 years and + 1 year both for men and women).

50. Hunink *et al.* (1997) showed that 43 % of the decline in coronary heart disease (CHD) observed between 1980 and 1990 resulted from improvements in acute treatment and that 29 % resulted from improvements in secondary prevention, *i.e.* medications to reduce blood pressure

---

9 . The difference between DFLE and HALE is that the former employs a dichotomous disability measure, while the latter uses a disability measure that has different levels that are then combined into a single value using utility weights that are specific for each level of disability. One advantage of the HALE method as applied by WHO is that it has been designed for use in a variety of countries with very different levels of data availability. However, its reliance on expert opinion for the development of the weights used for each condition requires assumptions (frequently untested) to be made about the relation between the condition and other factors such as age, sex, and interactions with other conditions.

10 . See Oliveira Martins *et al.* (2005), Table 2.4.

and cholesterol level. Cutler, Landrum and Stewart (2006) conclude that improved medical care for CHD explains up to 70 % of mortality reduction in the US over the period 1984 to 1999. For England and Wales, 42 % of the decrease in CHD mortality between 1981 and 2000 was found attributable to medical and surgical treatment (Unal *et al.*, 2004). Similar results were found for Scotland and the Netherlands (Capewell *et al*., 1999; Bots and Grobbee, 1996)).

51. Some results are also available concerning the impact of health care on reduced disability. Cutler, Landrum and Stewart (2006) show that improved medical care explains up to 50 % of the reduction in disability caused by cardiovascular disease in the US over the period 1984 to 1999. The increase in quality-adjusted life expectancy for these patients is around 3.7 years. Cutler (2003) show that intensive procedures such as hip replacement and other surgeries rose particularly for people with musculoskeletal problems between 1989 and 1999 lead to a large decline in disability during the same period.

52. This evidence suggests that investment and spending in health care have had a positive impact on the health status, supporting the "healthy ageing" regime experienced in US, Europe and Japan. What is the likelihood for such a regime to be maintained in the future? Actually, three scenarios have been considered in the literature, illustrated in diagram 2.1. Scenario I corresponds to the "compression of morbidity" hypothesis, an optimistic theory suggested by Fries (1980). In that case there would be a reduction in morbidity and disability in the last ages of life. Life expectancy would be close to disease-free and disability-free life expectancy. At the other extreme, scenario II, corresponds to a pessimistic "expansion of morbidity" (Gruenberg, 1980), Kramer, 1980), where all gains in longevity translate into years in poor health. An intermediate hypothesis can be considered (Manton, 1982), such as scenario III, where the gains in longevity gains translate one-to-one into years in good health (or "healthy ageing").

[Diagram 2.1: Three possible scenarios for future changes in morbidity at a given age]

53. Based on the data reviewed here, there is certainly reason for hope that countries can achieve a healthy ageing regime, but this is in no way assured. This is in line with theoretical research which suggests that different patterns may evolve over time within the same country (Michel and Robine 2004). In this model the aging population is based on a cyclical movement where, first, sicker people survive into old age and disability rises, then the number of years lived with disability decreases as new cohorts of healthier people enter old age but, finally, the number of years lived with disability rises again, when the average age of death rises so much that many people spend their last years at an advanced age burdened by multiple chronic illnesses and frailty. If this is the case then achieving healthy ageing seems possible but by no means assured, and if achieved it may not be permanent

54. Looking ahead, a particular concern about the ability to maintain a healthy ageing regime arises from the extrapolation of recent trends in obesity, a challenge that is afflicting the US above all, yet many European countries are showing very similar, if delayed trends. Several studies in the US have documented a surprising increase in functional limitations among the middle-aged, caused by obesity, with obviously detrimental effects on late life functioning

(Lakdawalla, Bhattacharya and Goldman 2001; Freedman, Martin and Schoeni 2004). This research suggests that at least in the US (where the compression of morbidity thesis has thus far received rather widespread empirical support, *e.g.* Fries, 2005) there is reason to expect a reversal of the hard-fought gains of functional decline. To the best of our knowledge no comparable findings exist for Europe, which is more a reflection of lack of suitable data than of the absence of the problem. But if the US results are any guide for what might happen in Europe, then the findings reinforce the importance of an active lifestyle and low-risk health habits such as avoiding obesity in maintaining functional independence into the advanced years. Although technology, the built environment, and medical care advances may have yielded benefits in function and quality of life thus far, unless the health habits of the baby boomers change dramatically, the healthy ageing regimes that have occurred may indeed only be a short-live phenomenon.

2.4 The optimal level of health expenditures

2.4.1 The value of health

55. One way to assess the value of health is to measure the extent to which one is willing to trade off health for specific market activities for which a price exists. This is the principle of, so-called, willingness-to-pay studies. Namely, the "value of a statistical life" (hereafter, VSL), can be inferred from risk premiums in the job market: jobs that entail health risks, such as mining, pay more in the form of a risk premium. VSL can also be estimated by analysing market prices for products that reduce the likelihood of fatal injury. The VSL literature leads to estimates ranging from about two million dollars to nine millions dollars (Viscusi and Aldy, 2003), Ashenfelter and Greenstone, 2004); Murphy and Topel, 2005). Reviewing the literature, Cutler (2004) considers that a low-bound of $ 100,000 per year of life saved could be adopted.

56. Assuming a VSL of $100,000 per year, Cutler and McClellan (2001) examine whether new treatments of heart attack that extends life expectancy of one year are worth additional costs. The present value of the VSL is about $70,000, while the increase in the cost of treatment is around $10,000 per year. They conclude that the return of technological change in heart attack treatments is high 1:7. For depression, the time spent in an ill-condition is reduced by height weeks with new treatments. This amounts to a benefit of about $6,000, around 6 times greater than the cost of treatment ($1,000). This evaluation could be conservative, as it does not take into account the social gains arising from the fact that an individual with better health is able to work more, for example by new treatment for depression could reduce the probability of early retirement (Conti *et al.* 2006). For cataract the result is even more impressive: the present value of benefit is equal to $95,000, to compare with a cost for the operation equal to about $3,000.

57. Cutler *et al*. (2006) find that and increased spending on health care at birth resulted in an average cost of $19,900 per year of life gained (for the period 1960-2000). Assuming that 50% of improvements in longevity resulted from medical care (Bunker 2001, 1995; Bunker, Frazier and Mosteller 1994) conclude that health care led to gains in welfare. Using life-year values of $99,000 to 173,000, and conservatively considering only the health care-related improvements in survival

over the past two decades, they find that one dollar health care spending in the US could generate from $1.55 to $1.94 (see also Luce *et al*., 2006).

58. Murphy and Topel (2006) provided undoubtedly the most striking result in this respect. Using individuals' willingness to pay, they found gains in life expectancy from 1970 to 2000 to have added to US wealth a gain of around 50 % of the annual GDP! Rising medical expenditures (reaching around 14% of GDP in 2000) would have absorbed only 36 % of the value of increased longevity. The authors distinguish between length and quality of life: life extension is valued because utility from goods and leisure is enjoyed longer, and improvement in the health status raises utility from given amounts of good and leisure. They show that the social value of improvements in health is an increasing function of the size of the population, the lifetime income, the existing level of health and of the proximity of the ages of the population to the age of most disease onset. These factors make it possible to predict that the valuation of health improvements will continue to rise in the future, as the population and incomes grow, especially because the baby-boom generation approaches the age of disease-related death. Finally, they show that improvements in life expectancy raise willingness to pay for further improvements in health by increasing the value of remaining life.

59. These potentially large welfare gains interact with the adoption of technological innovations that, in turn, are a major driver of expenditures. Goldman *et al.* (2005) shed some light on this issue. They set up a micro-simulation model for US *Medicare* enrollees, which makes it possible to construct simulated health histories for individuals. Transition probabilities are estimated on a sample of about 100,000 *Medicare* beneficiaries observed between 1992 and 1999. With this framework, individual yearly probabilities of dying, health conditions or disability state can be estimated. In turn, these probabilities can be changed to simulate the impact of health improvements from new technologies. Ten selected technologies were selected and their impact on *Medicare* costs by 2030 is projected.

60. Table 2.2 summarises the results for three of these technologies: an intra-ventricular cardiovascular defibrillator, prevention of Alzheimer's disease and a (hypothetical) chemical Compound that extends life span. The three are cost-efficient in the sense that the cost of one year saved is lower or equals $ 100,000 (low bound for the one year of life). Prevention of Alzheimer's and the compound that extends life span have about the same annual cost, but the compound is much more efficient in terms of health outcomes. Accordingly, the compound is much more costly in the long run: +13.8 % (and 70.4 % in the case of morbidity expansion) instead of + 8 % for the Prevention of Alzheimer's disease. Based on these results, Lubitz (2005) draws rather strong two conclusions: all technological advances add costs that overwhelm any savings from improved health; and, the impact of a new treatment on long term costs is directly connected to its efficiency in terms of number of years of saved life (not the health status). Put differently, investing in medical innovations increases costs but could provide a reasonable value for money because it 'buys' more longevity.

[Table 2.2 Micro simulation results for three technologies by the Future Elderly Model]

2.4.2 Estimating the optimal health care spending share

61. At this point the question is what could be the optimal level of health expenditures? Hall and Jones (2007) proposed a model where the key parameter is the curvature of the marginal utility of consumption (γ). If γ is high, the marginal utility of consumption of non-health goods declines quickly and the optimal share health spending rises rapidly, this growth reflecting a value of life that grows faster than income (a simple static version of this model is spelled out in Box 3).

Box 3. The model of Hall and Jones (2007)

Denote by *x* the individual's health status, which is assumed to be equal to its life expectancy (i.e. "healthy ageing"). The mortality rate of the individual is thus equal to *1/x*. *y* is the individual's income; *c* consumption, which is supposed to be stationary over the life cycle and *h* health expenditures. Expected lifetime utility for the representative individual is then defined by:

$$U(c,x) = \int_0^{\infty} e^{-(1/x)t} u(c) dt = x\,u(c) \qquad (1)$$

The income can be spent either on consumption or health:

$$c + h = y \qquad (2)$$

A health production function defines the value of health for a given level of expenditures *h*:

$$x = f(h) \qquad (3)$$

The optimal allocation of resources maximizes the expected lifetime utility (1) subject to the budget constraint (2) and the health production function (3). The problem of the individual becomes:

$$\underset{c,h}{Max}\ f(h)\,u(c) \quad \text{s.t.} \quad c + h = y$$

The first-order conditions for this problem imply that the marginal benefit of saving a life equals the marginal cost of saving a life. Let $L(c,x) = U(c,x)/u'(x)$ denote the value of life in units of output. The optimal allocation of resources verifies:

$$L(c,x) = \frac{x^2}{f'(h)} \qquad (4)$$

The share of income devoted to health expenditures is denoted by *s =h/y*. The elasticity of the health production function with respect to health expenditures is denoted by η_h and the elasticity of the utility function with respect to consumption by η_c. From condition (4), one can derive that the optimal share of income devoted to health care (i.e. the share that maximises social welfare) verifies condition (5):

$$s = \eta_h = \frac{L(c,x)/x}{y} \qquad (5)$$

The production elasticity is likely to fall as spending rises. Therefore, from condition (5) it can be seen that the optimal share of income devoted to health care s increases if the value of one year of life $L(c,x)/x$ rises faster than income. This condition can also be expressed as follows :

$$\frac{s}{1-s} = \frac{\eta_h}{\eta_c} \quad (6)$$

This shows that a rising share of income devoted to health care is optimal if η_c is decreasing more rapidly than η_h. The thrust of the argument behind this result is that satiation occurs more rapidly with non-health rather than with health consumption.

Does the rising share of health expenditures observed in all developed countries fit collective preferences? In other words, are preferences likely to meet condition (6)? Let us assume a standard utility function:

$$u(c) = b + \frac{c^{1-\gamma}}{1-\gamma} \quad (7)$$

Empirical literature suggests that $\gamma = 2$, or at least that $\gamma > 1$. These values imply that the marginal utility of consumption declines quickly, which is a condition for the value of life to grow rapidly. From (7), one can derive the expression of the value of one year of life:

$$\frac{L(c,x)}{x} = b\,c^{\gamma} - \frac{c}{\gamma - 1} \quad (8)$$

With $\gamma > 1$, the value of one year of life will grow faster than consumption and income. This implies that the optimal health share s should rise over time.

62. To see how technology interacts with preferences, Hall and Jones (2007) consider a health production function, *f(h)* (equation (3), Box 3), of the following form:

$$x = (zh)^{\theta} \quad (9)$$

63. Where the technological progress is denoted by *z*. Hall and Jones (2007) set up a full dynamic model that allows for age-specific mortality, age-specific elasticities of the health production function (θ_a, for a given age a), as well as growth in total resources and productivity growth in the health sector. The health production function identifies three different causes in the decline in age-specific mortality: technological progress in health care, resource allocation (*i.e.* the share of income devoted to health spending), and others causes (pollution, education, trends in risky behaviors such as smoking, etc.). Depending on assumptions relative to the pace of technological progress, Hall and Jones find that technological progress and increased health spending account each for around 1/3 of the decline in age specific mortality.

64. The marginal cost of saving a life can be derived from the health production function (Table 2.3). Hall and Jones obtain a baseline value of about $1.9 million for an individual aged 40-44. With this VSL, the current level of health expenditure in the US is roughly optimal for this age group. With higher VSL health spending would still be too low.

[Table 2.3 Estimated marginal cost of saving a life]

65. The optimal share of health spending depends on various assumptions regarding preferences and the value of life. Hall and Jones (2007) use a benchmark of γ=2, but simulations

are also performed for γ=2.5, 1.5 and 1.01. Income per person is assumed to grow at an average (historical) rate of 2.3% per year. The simulations suggest that a rising share of the spending devoted to health care is a robust feature of the optimum, as long as γ is not too small , which is equivalent to say that health is a superior good (Figure 2.13). Only at the extreme case where γ=1.01, the marginal utility of consumption falls more slowly than the diminishing returns in the production of health, implying that the optimal health share declines over time (cf. equation (6) Box 3).

[Graph 2.13: The increase in the optimal share of spending devoted to health care]

66. To complete the picture, Figure 2.14 shows how the optimal share of health spending depends on assumptions regarding the value of life and the pace of technological progress. The assumption relative to VSL influences positively the optimal level of health share. Conversely, the higher the productivity gains in the health production function the lower the optimal level of the health share in GDP. Overall, the optimal health spending is invariably high from 23% percent in the case where γ=1.01 to 45%. These results suggest that historical and future increases in the health spending share may be desirable from a welfare-enhancing point of view.

[Graph 2.14: The optimal share of spending devoted to health care]

67. To sum-up, we have learned key insights about the links between expenditures, health status and welfare:

- Technological progress, instead of ageing, is the main driver of health expenditure growth.
- Two mechanisms are involved in technological progress in health care, substitution and extension, where more goods are available and consumed. The growth in health expenditures is mostly explained by the extension effect.
- The diffusion of technologies has led to additional costs but also generated value in terms of longevity and better health, so that it contributes to welfare. Indeed, evaluating the gains in welfare induced by more longevity and health could lead to big numbers.
- The results suggest that that if social welfare maximisation is the objective, current levels of health expenditures may even be below the socially desirable level, thus future increases in health expenditures may be seen as a positive development. Nevertheless, the desirability of higher spending levels does not by itself solve their institutional feasibility and fiscal sustainability. In particular, the perspective of spending pressures calls for a particular careful design and accountability of public institutions dealing with health care provision, and probably a higher participation of the private sector in its financing.

3. The influence of income growth on health care expenditures

68. We have just seen that the crux of the Hall and Jones' argument for a rising share of the health consumption in GDP was the fact that the marginal utility of consumption of non-health goods falls relative to that of health as income rises. In other words, as satiation occurs more rapidly in non-health consumption than in health, the latter can be viewed as a superior good (or its income elasticity is greater than one). As we show in the Annex I, this result also depends critically on the specific form of the utility function, notably the presence of the constant term (cf. equation (7) in Box 3). But the claim that health is a superior good is not new. Since Newhouse (1977) an extensive empirical literature has seek to estimate the elasticity of health expenditures with respect to income.

3.1 Is Health really a luxury good?

69. Whether health care is a luxury (income elasticity above one) or a necessity (elasticity below one) is still an unsettled issue. This is unfortunate since many projection models rely on an assumption regarding this elasticity, which is also crucial to derive estimates of the effect of technological progress at an aggregate level. Getzen (2000) argues that empirical studies often failed to distinguish between sources of variation between groups and within groups: an individual within an insured group may have little reason or incentive to limit health expenditures, especially if the group is large and the individual's effect on the group is relatively insignificant, thus that individual's health care spending is insensitive to income. In contrast, the group's total expenditure on health care is limited by aggregate income. Therefore, total group spending will be more responsive to income than individual spending, and wider groups (countries) will be even more responsive. This stylized fact points out the importance of heterogeneity across groups of agents. The fact that micro-level estimates might be quite different from the ones at the aggregate level is due to specific constraints, which do not necessarily apply at the macro level. Note also that there is no specific reason to expect a micro reduced form to hold at the macro level.

70. In general, the higher the level of aggregation, the higher the estimated income elasticity of health care spending. Studies at the individual level show that the majority of the variation in spending (50% to 90%) is associated with individual differences in health status, while income elasticities are small or even negative (Newhouse and Phelps, 1976; Manning et al., 1987; Sunshine and Dicker, 1987; Wagstaff et al., 1991; AHCPR, 1997). However, analysis of pre-1960 data where insurance is less prevalent and most payment are made out-of-pocket show a much larger income elasticity (0.2 to 0.7). Similarly, consumption of dentistry, plastic surgery, counselling, eyeglasses and other types of care show income elasticities that are strongly positive and sometime substantially exceed 1 (Parker and Wong, 1997). In contrast, at the macro level, studies of national health expenditures consistently show income elasticities greater than one—health care is a luxury good—with above 90% of cross-sectional and time-series variation explicable by difference in per capita income, and differences in health status having negligible effects (Abel-Smith, 1967; Kleiman, 1974; Newhouse, 1977; Maxwell, 1981; Leu, 1986; Culyer, 1988; Getzen, 1990; Gerdtham et al., 1992).

3.2 An econometric investigation

71. Against this background, we provide new evidence on the elasticity of demand for health by using different panel estimators and various explanatory variables. In particular, we propose new evidence on the elasticity of per capita public, private and total health care services. The base model is essentially a reduced-form, with the choice of right-hand side variables influenced by the numerous contributions on the possible determinants of health care spending.[11] Newhouse (1972), for instance, assumed that per capita GDP is the main determinant of per capita health care expenditures:

$$HCE_{i,t} = \alpha_i + \beta Y_{i,t} + u_{i,t} \tag{10}$$

72. Where $HCE_{i,t}$ stands for health care expenditures, $GDP_{i,t}$ is per capita GDP, $u_{i,t}$ is an error term, $t = 1, \cdots, T$ (number of periods) and $i = 1, \cdots, N$ (number of countries). However, other right hand side variables may be considered, as a trend to capture technology advances or health price discussed in the previous section. In this context, the risk for omitted variable bias can be high. Recent studies (Hall and Jones, 2004; Okunade and Murthy, 2002; Blomqvist and Carter, 1997) have stressed that the observed increasing health care expenditure as a share of GDP is likely due to other factors, such as insurance covering, etc. Di Matteo and Di Matteo (1988) also argue that because health is labour intensive, its cost may increase as a function of average income, so that measured income elasticity is blurred by the price effect. Moreover, since the price elasticity is presumably negative, the income coefficient is likely to be biased downward. This conflicting evidence suggests testing the robustness of standard estimates using various explanatory variables. A reduced-form model is also exposed to the well-known endogeneity bias.

73. Concerning econometric methods, different approaches have been used in the literature: (i) cross-section analysis, (ii) time series analysis and (iii) panel analysis. Two key issues are the degree of heterogeneity and the finite sample bias of standard time series estimates (especially as T is small). As panel data techniques are a standard method to deal with heterogeneity issues, this option was followed here.

74. Keeping in mind the limitations of this exercise, we conduct a simple econometric test, to illustrate how the estimates of the health spending income elasticity can be sensitive to different specifications. We consider three samples. The first sample (group 1) corresponds to a unbalanced panel of the 30 OECD countries for the period 1970-2002. The second sample (group

11. To explain the results of the macro elasticity of demand for (per capita) health care services with respect to (per capita) income, a first strand of explanations focuses on data. In this respect, one can quote the comparability of OECD data on health care expenditures, the definition of (per capita) GDP, the sampling period, and the transformation of variables (log-transformation, PPP-adjusted measure). See Hansen and King, 1996; Blomquist and Carter, 1997; Gerdtham et al. (1992).

2) corresponds to a nearly balanced panel of 19 OECD countries.[12] The last sample (group 3) comprises 17 OECD countries over the same time period.[13] The data are from the OECD Health Data Base (2005).

75. We conduct separate regressions for per capita public, private, and total health care expenditures. For each variable, we consider a subset of the following explanatory variables: per capita GDP; a trend over the period 1970-2002 (common across OECD countries), a trend (dummies variables) over the period 1970-79 (respectively 1980-89, 1990–99), as a loose proxy for role of technological change; the share of young (0-14), middle-age (15-54) and old-age people (55-74) over the total population, the share of very old people (75+) serving as the reference group; and three dummies variables, which control respectively for the existence of gate-keeping and for the type of health care system (public or integrated).

76. In our investigation, four different specifications are tested. First, the pooled regression model (health and GDP variables are in logs):

$$HCE_{i,t} = \alpha + \beta GDP_{i,t} + \gamma X_{i,t} + u_{i,t} \tag{11}$$

where $X_{i,t}$ is a set of regressors.

77. The one-way fixed effects model (in the individual dimension), where α_i denotes the i^{th} individual effect:

$$HCE_{i,t} = \alpha_i + \beta GDP_{i,t} + \gamma X_{i,t} + u_{i,t} \tag{12}$$

78. The two-way fixed effects models, where λ_t denotes the t^{th} temporal effect:

$$HCE_{i,t} = \alpha_i + \lambda_t + \beta GDP_{i,t} + \gamma X_{i,t} + u_{i,t} \tag{13}$$

79. Finally, the one-way error component model (in the individual dimension) where $\alpha_i \sim N(o, \sigma_\alpha^2)$:

$$\begin{aligned} HCE_{i,t} &= \alpha + \beta GDP_{i,t} + \gamma X_{i,t} + v_{i,t} \\ v_{i,t} &= \alpha_i + u_{i,t} \end{aligned} \tag{14}$$

80. Table 3.1 to 3.3 report the results of the pooled OLS regressions. *P*-values are in brackets and standard errors have been determined using the White's correction or the Arellano's correction. Several points are worth commenting. Overall, results are robust across groups and

12. Group 2 includes Australia, Austria, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, the United Kingdom, and the USA.

13. Group 3 excludes Luxembourg and the Netherlands from Group 2.

across time period.[14] First, the income elasticity depends on the nature of health care spending. Income elasticity is in general below or close to one in the case of per capita private health expenditures whereas it exceeds one when considering per capita public or total health expenditures. Second, the inclusion of a common trend or time dummies over sub-periods leads to a decrease of the income elasticity, though it remains largely above one. Third, the population variables are often statistically significant at conventional levels, but their sign depend on the specification. They tend to be positive for public and total expenditures, while negative for private expenditures. The latter could be coherent with the fact that public systems providing universal coverage are more affected by demographic factors.

[Table 3.1-3.3 Pooled OLS Regressions –Per capita health expenditures, public, private and total]

81. These results confirms earlier results, at least for per capita total health expenditures, in the sense that cross-sectional model estimates of the GDP elasticity of HCE are typically above unity (Gerdtham and Jonsson, 2000).[15] Nevertheless, cross-sectional models are fragile in small data sets and use an implicit assumption of homogeneity across countries. This leads to unrealistic assumptions such that the homogeneity of tastes, preferences and production functions across countries as well as the homogeneity of health systems. This could severely bias (Im, Pesaran, and Shin, 1995).

82. In contrast, panel estimates offer a number of advantages over cross-sectional or time-series studies (see Baltagi, 2005). In particular, having multiple years of data for each country enables to include (time) country-specific fixed (or random) effects, thereby controlling for a wide range of time-invariant country characteristics, which may bias the estimate of income elasticity in cross-section (or time-series analysis). Table 3.4 to 3.6 reports estimates of the one-way fixed effects model in the individual dimension. Since the dummy variables (gate-keeping, public system and integrated system) are not time-varying, they cannot be estimated.[16]

[Table 3.4-3.6 One-way fixed-effect regressions –Per capita health expenditures, public, private and total]

83. Interestingly, the inclusion of a common time trend significantly reduces the income elasticity below one. If this common trend can be interpreted as technology advances, then it confirms the fact that neglecting the role of technology change tends to bias upward long-term income elasticity (Dreger and Reimers, 2005). At the same time, we assume here that cross-section effects are independent. This assumption may lead to spuriously interpret this common

14. We also estimate the cross-section regressions over the period 1980-2002. Estimates are quite close to the pooled estimates. Results are not reported here but are available upon request.

15. A non-exhaustive list includes Cullis and West (1979), Leu (1986), Parkin et al. (1987), Culyer (1990), Gerdtham and Jonsson (1991a, b), Hitiris and Posnett (1992).

16. Using the method suggested by Canova (2007), we also regressed the individual effects on these variables. Results are generally not statistically significant.

trend as technology progress in the sense that other factors may explain this term when accounting for cross-sectional dependence. For instance, this trend may also reflect the effect of relative prices. A second result is that the income elasticity further decreases when introducing the population variables. These variables have the expected sign in the case of per capita public and total health care expenditures. All in all, the third regression ([3]) displays the highest R^2 and the unexplained residual is negligible. When testing the pooled model against the one-way fixed effects model, the test statistic strongly supports the latter. Finally, the introduction of time dummies yields higher income elasticity and unexpected signs on population variables. Note also that they are often statistically insignificant.

84. To further assess the role of the time dimension, we ran two-way fixed effects regressions (Table 3.7). Except for few estimates of the per capita private health care expenditures regressions, we consistently find the income elasticity to be below one. Specification ([3]) is preferred by standard specification tests. However, there is no clear cut evidence between the one-way and two-way fixed effects models.[17]

[Table 3.7 Two-way fixed-effect regressions - Per capita health expenditures, public, private and total]

85. Finally, we also tested the one-way error component model in the individual variables for each type of per capita health care expenditure (Tables 3.8 to 3.10). The variance-covariance parameters are estimated using the Swamy-Arora method.[18] Results are fairly close to those of the one-way fixed effects model.[19] Overall, results confirms that the inclusion of a common trend significantly lower the income elasticity (below one).[20]

[Table 3.8-3.10 One-way error component model - Per capita health expenditures, public, private and total]

86. Some caveats are in order. First, we assume that variables are not integrated nor it exists a co-integration relationship. Second, we assume that there is cross-sectional independence. Third, income elasticity is obtained from a reduced-form equation in which potential important determinants are not taken into consideration due to missing or reliable data. Moreover, we disregard the endogeneity problem of per capita GDP by choosing not to instrument the previous regressions (although the determination of non redundant and reliable instruments is a

17. Results are not reported here but are available upon request.

18. Results are robust to other methods.

19. The Hausman and Augmented-Hausman tests tend to favour the latter specification. Note that the use of one-way or two-way error component model could be questionable since OECD countries represent a closed population, i.e. the sample population is the same as the total population.

20. We also ran a one-way error component model in the time dimension as well as a two-way error component model, previous results are quite robust. Results are not reported here but are available upon request.

difficult task in the present setting). Fourth, we suppose that heterogeneity is modelled through individual or time effects, and random effects. Finally, the specifications retained here are static. Omitting dynamics may substantially bias our results. Additional tests for the existence of a co-integration relationship, cross-sectional dependence and convergence were also carried out, but to save space are not reported here.[21] They do not change qualitatively the results concerning the value of the income elasticity.

87. To summarise, our econometric estimates tend to favour the assumption of an income elasticity equal to or below one. This contradicts somewhat the critical assumption used by Hall and Jones (2007), as well as other studies, to derive their projections. Nonetheless, unitary income elasticity is not a low value in absolute terms. It implies that, *ceteris paribus*, health expenditures will grow in line with GDP per capita. In consequence, public health care budgets should not rely on economic growth to smooth or reduce expenditure pressures related to the health sector.

4. Projecting aggregate health spending

88. In trying to foresee how much resources will be devoted to health care spending and investment, we have seen above that the different drivers of expenditure can be broadly classified into *demographic* and *non-demographic* factors.

4.1 Demographic drivers of expenditure

89. Assessing demographic drivers requires the breakdown of health expenditures by age groups. These data are relatively scarce. For public expenditures, an average profiles by age is available for the year 1999 (Figure 4.1).[22] As discussed above, the shape of these expenditure curves reflects the interaction between health care costs at the proximity to death and mortality rates. While mortality rates increase with age, the costs of health care near death (or 'costs of death') tend to be higher at young and prime age than for elderly people (Aprile, 2004). This explains why expenditures first increase with age, then peak and after decline at very old ages. The little spike in health expenditures at the beginning of the curve is just related to early infant mortality being higher than young and prime-age mortality.

[Figure 4.1 Public health care expenditure by age groups]

90. For European countries, public expenditure profiles can capture well the profile of total expenditures. For the United States, where private expenditures play an important role, the available breakdown of public and private expenditures shows that the sharp increase in health

21. These results are available upon request. As a robustness check, we assume that the slope coefficients can be different across groups of countries. Empirical evidence stills tends to support the assumption of an income elasticity equal to or below 1. For further details see Oliveira Martins and Pelgrin (2007).

22. For European countries, the data is based on the EU-AGIR Project; see Westerhout and Pellikaan (2005).

expenditures at older ages is also only observed for public expenditures (Figure 4.2). Private expenditures tend to peak in the age group of 50-60 years old, but then decline afterwards.

[Figure 4.2 Public and private health care expenditure by age groups, US]

91. On the basis of these expenditure profiles and population estimates, the expenditures on those aged over 65 is around four times higher than on those under 65. The ratio rises to between six to nine times higher for the older groups (Productivity Commission, 2005; OECD Health Database, 2005). As discussed in section 2, this fact is not a reason for expecting demographic pressures to be a major driver of the growth in health expenditures.[23] Indeed, one should take into consideration a dynamic and positive link between health status and longevity gains, reflecting a "healthy ageing" process. This is likely to lower the average cost per individual in older age groups, all the more so as major health costs tend to come at the end of life.

92. For the purpose of projecting health expenditures is seems then convenient to disentangle the expenditures survivors and non-survivors. The expenditures for the *non-survivors* can be estimated by multiplying the health costs near to death by the number of deaths per age group. Here the proxy for the 'costs of death' is the health expenditure per capita for the group 95+, assuming that after this age all health costs are death-related. This amount was then multiplied by a factor, equal to 4 for an individual between 0 to 59 years old[24] and declining linearly to 1 afterwards, to reflect the decline of the 'costs of death' with age.

93. The expenditure curve for *survivors* is simply derived by subtracting the death-related costs just described from the total expenditure curves, when available (18 OECD countries). Given the uncertainties surrounding these data, it seemed preferable to estimate an average expenditure curve for survivors and then calibrate this curve for each country. In this way, the projections are less sensitive to initial conditions and to country-specific data idiosyncrasies. This average expenditure curve for *survivors* was estimated econometrically in a panel of 18 countries by 20 age groups, using a spline function, as follows:

$$\left.\frac{\text{Health Exp.}}{\text{Population}}\right|_{age\ group} = -137.8 \cdot age + 9.94 \cdot age^2 - 0.29 \cdot age^3 + 0.004 \cdot age^4 - 0.00002 \cdot age^5 + 1222.6$$

where *age* is the central point in each age bracket (*e.g.*, 2, 7, 12,…, 97). All the estimated coefficients are significant.

23. The effect of ageing on health expenditures per capita has also been weak in the past, see Culyer (1990), Gerdtham *et al.*, (1992), Hitiris and Posnett (1992), Zewifel *et al*. (1999), Richardson and Roberston (1999), Moise and Jacobzone (2003) and Jönsson and Eckerlund (2003).

24. This proportion is based on Aprile (2006) and some evidence gathered by the EC-Ageing Working group (EC-EPC, 2005). The results are not very sensitive to the alternative assumptions, because mortality rates are rather low for young and prime-age people.

94. Under the hypothesis that health costs are mostly death-related, the projected increase in life expectancy must be accompanied by an equivalent gain in the numbers of years spent in good health. Otherwise, an increasing share of the population living in "bad health" would emerge and health care costs would then cease to be mainly driven by the costs of death, as initially assumed (*q.e.d.*).

95. In such a scenario, the expenditure curve for *survivors* is allowed to shift rightwards in line with longevity gains, progressively postponing the age-related increases in expenditure.[25] This development tends to reduce costs compared with a situation in which life expectancy would not increase. The baseline projections presented in this paper follow this "healthy ageing" scenario, but the sensitivity of the results to alternative assumptions is also tested below.

96. As regards *non-survivors*, two different effects are at play. On the one hand, the number of deaths is set to rise due to the *transitory* effect of the post-war baby-boom. On the other hand, if mortality falls over time, due to a *permanent* increase in longevity, fewer will be at the very end of life in each given year, mitigating health care costs.[26] The total effect on public health care expenditures will depend on the relative size of these effects.

4.2 Non-demographic drivers of expenditure

97. As discussed in the previous section, a reasonable approach seems to assume an income elasticity equal to one and, subsequently, to test the sensitivity of the projections to this assumption. Assuming unitary income elasticity, Oliveira Martins and de la Maisonneuve (2006) estimated the average residual growth for OECD countries at around 1 % per year for the 1990s. The central expenditure projections assume this average residual growth. There are at least two reasons for common assumption in the context of long-run projections. First, in countries where cost-containment policies have resulted in a low or negative residual (*e.g.*, Austria, Denmark, Ireland, Italy, Sweden) there could be a trend reversal, e.g. because new personnel has to be attracted or run-down facilities renewed. Second, in countries where the residual growth was very high (*e.g.*, Portugal, United States) it may seem likely that cost-containment policies will be implemented in the future. These effects would lead to a certain cross-country convergence of the expenditure residual over time.

25. In contrast, in "pure demographic" projections (see Dang *et al.*, 2001), the expenditure curves would not shift rightwards with longevity, reflecting the implicit assumption of unchanged health status at any given age. When the cost curves stay put in presence of longevity gains, the share of life lived in 'bad health' increases when life expectancy increases. This corresponds to the "expansion of morbidity" scenario referred to in section 2.

26. See for example Fuchs (1984), Zwiefel *et al.* (1999), Jacobzone (2003) and Gray (2004).

4.3 Projection model for health care expenditures

98. Defining HE, Y and N as real health care expenditures, real income and population, respectively; and, ε the income elasticity of health expenditures and NDF the other non-demographic factors, the growth of health expenditures can be decomposed as follows:

$$\Delta \log\left(\frac{HE}{N}\right) = \Delta \log(Adjusted\ age\ factor) + \varepsilon \cdot \Delta \log\left(\frac{Y}{N}\right) + \Delta \log(NDF) \qquad (15)$$

or expressed in share of expenditure to GDP:

$$\Delta \log\left(\frac{HE}{Y}\right) = \Delta \log(Adjusted\ age\ factor) + (\varepsilon - 1) \cdot \Delta \log\left(\frac{Y}{N}\right) + \Delta \log(NDF) \qquad (16)$$

99. Intuitively, the mechanical effect of population ageing on expenditures can be seen as moving up along the expenditure curve, assuming that the age profile of expenditures remains constant over time. This demographic effect is adjusted for the 'healthy ageing' by shifting the expenditure curve rightwards, implying that older people still cost more than the young, but at progressively older ages. Finally, the cost curve shifts upwards due to non-demographic drivers (income and other non-demographic effects).

100. In order to make the projections less sensitive to the starting year and allow for some convergence of expenditures to GDP across countries,[27] the total logarithmic growth rates derived from equation (16) for each country are applied to the OECD cross-country average expenditure share to GDP in 2005 (a sort of "representative" country). The changes in expenditure shares calculated from this common base are then added to the country-specific shares in 2005 to obtain the projected ratios of expenditure to GDP (see Annex II).

---

27. Without this specification, spending patterns of countries with equivalent expenditure drivers would diverge in terms of share of expenditure to GDP merely due to different initial expenditure to GDP ratios. Such a divergent scenario is not very appealing in the context of long-term projections. This issue has been explored in a few empirical papers. Hitiris (1997) examines total health expenditures convergence for a group of 10 European countries and finds no evidence of convergence. Narayan (2007) examines the catch-up hypothesis, especially whether or not per capita total health expenditures of the Canada, Japan, Switzerland, Spain, and the United Kingdom converge to those of the US over the period 1960-2000. He uses univariate and panel LM unit roort tests that allow potentially for structural breaks and provides evidence of relative convergence when incorporating one or two structural breaks (see also Barros, 1998; Okunade and Karakus, 2001).However, the unit root approach of convergence has been criticized on the ground that non-stationary processes can meet the definition of convergence (Nahar and Inder, 2002; Bentzen, 2005). In a companion paper, Oliveira and Pelgrin (2007) investigate the convergence hypothesis for per capita public, private, and total health care expenditures using the recent approaches developed by Nahar and Inder (2002) and Phillips and Sul (2007). The results support the hypothesis of convergence of GDP and total health expenditures per capita. Health expenditures as a share of GDP also converge across countries.

101. Additional exogenous assumptions underlying the projections are listed in Box 4 (more details are also provided in Annex II).

Box 4. Exogenous variables and assumptions underlying the projections

The projections require a set of exogenous data, as follows:

(1) Population projections (*N*). The population projections were gathered by the OECD Directorate on Employment, Labour and Social Affairs, directly from national sources.

(2) Labour force projections (*L*/*N*) rely on Burniaux *et al.*(2003). These projections are constructed in the basis of a, so-called, cohort approach. They correspond to a baseline scenario, i.e. the impact of current policies is assumed to influence labour participation over the next decades, but no additional assumptions are made concerning future policy changes.

(3) Labour productivity (*Y*/*L*) growth is assumed to converge linearly from the initial rate (1995-2003) to 1.75% per year by 2030 in all countries, except former transition countries and Mexico where it converges only by 2050.

The projected GDP per capita is directly derived from the above exogenous variables ($Y/N = Y/L \times L/N$). This simple framework is not supposed to capture in the best way productivity differentials across countries, but to isolate, as far as possible, the effect of ageing and other demographic factors on the projections. Further details can be found in Oliveira Martins and de la Maisonneuve (2006).

4.4 Expenditure projections for the US, EU-15 and Japan

102. The framework described above was used to project expenditures over the period 2005-2050. The demographic effects can be decomposed into the health care spending for survivors, the adjustment for "healthy ageing" and the death-related costs (panel A Figure 4.3). Pure demographic effects can be quite large for some countries, but they tend to be compensated by a better health status, as longevity increases. The death-related costs account only for a small fraction of the increase in expenditures as a share of GDP (to around 7% of total health care spending in the OECD by 2050).[28] The net effect of demographics on health care expenditures ranges from virtually zero in Sweden to nearly 1.5 percentage points of GDP for Slovakia. This can be mapped to differences in evolving old-age dependency ratios (Panel B of Figure 4.3). Admittedly, the "healthy ageing" assumption, albeit in line with observed patterns of morbidity regimes in the US and European countries, can be viewed as relatively optimistic.

[Figure 4.3 Demographic effects on public health care expenditure]

103. We carried out several simulations. In the scenario I it is assumed that, on top of the demographic effects, the expenditure residual grows at 1% per year over the projection period and the income elasticity is set to 1. In such a scenario a substantial increase in the health expenditures takes place, averaging nearly 5.3 percentage points of GDP from 2005-2050 (Table

28 . See Oliveira Martins and de la Maisonneuve (2006).

4.1). In nearly all countries, health care expenditures would then exceed 10% of GDP by the end of the projection period. The US expenditure share would reach 19% of GDP by 2050.

[Table 4.1 Projection for Total health care expenditures, scenario I]

104. In scenario II, we kept the same assumptions of scenario I but the income elasticity was set to 1.5, as some studies have projected expenditures assuming income elasticities well above one. Average expenditures will more than double with a projected increase of above 9 percentage points of GDP (Table 4.2). The income effect accounts around 4 percentage points of GDP in the US and EU-15. The expenditure share would reach 23% in the US, and around 16% of GDP and Europe and Japan by 2050.

[Table 4.2 Projection for Total health care expenditures, scenario II]

105. In scenario III, we kept the same assumptions as in same scenario I but the residual was set to 2% growth per year. This scenario is rather mechanical, as the sustained growth of the expenditure residual just compounds over time without limit. It illustrates, however, the type of assumptions that are required to generate the very high shares of health care to GDP put forward in some studies (such as Hall and Jones, 2007). On average, expenditures will more than double with a projected increase of above 12 percentage points of GDP (Table 4.3). The US expenditure share would reach 26% of GDP by 2050, and around 20% both in the EU-15 and Japan.

[Table 4.3 Projection for Total health care expenditures, scenario III]

106. Finally, in a voluntarily "cost-containment" scenario, the residual expenditure growth is assumed to grow at 1% per year, but converging to zero by 2050. This 'transversality condition' could be justified on the grounds that health care expenditures to GDP could not continue to grow at such constant rate, without limit.[29] A transversality condition may appear controversial in view of past experience. Under perfect health market conditions, a continuing increase in the share of income going to health care spending could reflect individual preferences, as discussed in section 2. But the health care market is not perfect and governments are footing most of the bill. Thus, rapid growth of the share of health care spending in income would have to be compensated by reductions in other public spending items, which may be difficult to achieve, and/or increased health care charges for individuals. Such cost sharing has already been introduced in most countries. This implicitly means that policies could progressively rein in the expenditure residual, *e.g.* by ensuring that future technology improvements are mainly used in a cost-saving way. This may imply some trade-offs. Reining in the impact of technological progress on health care demand without foregoing the benefits it provides to patients could be a challenging task.

107. The income elasticity was kept at 1, which would imply that public health care expenditure and income would evolve in parallel over the long-run. In other to be coherent with

29. Similar transversality conditions have also been imposed in other projection exercises. For example, Englert (2004) assumes that income elasticity ultimately converges to one.

a lower residual growth over the projection period, it was assumed that lower technology improvements lead to an "expansion of morbidity", implying that expenditure curves do not shift rightwards over time in line with longevity gains.

108. Under this scenario, public health care expenditures would still increase on average by nearly 4 percentage points between 2005 and 2050, from 7.8% to above 11% of GDP (cf. Table 4.4). Moreover, larger increases by 2050 are found in countries in Central and Eastern European countries, which are experiencing a rapid demographic change. In the US, the share of expenditure to GDP would be contained at around 18%.

Table 4.4 Projection for Total health care expenditures, scenario IV]

109. This projection illustrates how uncertainties concerning the parameters may drive different expenditure scenarios. Nonetheless, even in the mildest projections, the expected increase in the resources directed to health care are substantial, so the question to be answered now is the likely impact of these developments on the economic growth.

5. What is the impact of health on productivity and growth?

110. There are reasons to believe that health matters for growth, both through labour participation and productivity. First, health may impact labour supply. A good health status increases the time available both for work and leisure. Moreover, health also influences the decision to supply labour through its impact on wages, preferences and expected life horizon—the net effect depending on substitution and income effect. Second, healthier individuals could reasonably be assumed to produce more per hour worked, thus increasing productivity. Third, according to human capital theory, better health contributes to more educated people and thus more productive people. An increasing life expectancy will also encourage people to acquire more education. Fourth, the state of health of an individual (or the total population) is likely to impact not only upon the level of income but also the distribution of this income between savings and consumption and hence the willingness to undertake investment, which in turn promotes growth. Fifth, R&D in health, which represents a substantial share of total R&D, may contribute as an engine of innovation and growth.

5.1 Health, human capital and growth: general results

111. Since the seminal work of Becker (1964),[30] there is a sound theoretical and empirical basis to the argument that human capital matters for economic growth, but until recently, human capital has been mostly narrowly defined as education. At the same time, the idea of health representing—next to education—an important component of human capital was introduced most prominently by Grossman (1972), but has been acknowledged more widely. Grossman (1972) distinguishes between health as consumption good and health as a capital good. As a

30. In the original formulation of his theory, Becker (1964) pointed to health as one component of the stock of human capital, but then focused in his early empirical work exclusively on education.

consumption good, health enters directly into the utility function of the individual, since one enjoys being healthy. As a capital good, health reduces the number of days spent ill, and therefore increases the number of days available for both market and non-market activities. Health is not only demanded but also produced by individuals. They inherit an initial stock of health that depreciates with time, but they can invest to maintain and increase this stock. The production of health also requires the use of time by individuals away from market and non-market activities. These two ideas have been introduced in endogenous growth models.

112. Van Zon and Muysken (2001) analyze the trade-off between health and human capital accumulation in the endogenous growth framework of Lucas (1988). Health influences inter-temporal decision-making in three different ways. First, health generates positive utility of its own, through the average health level in the economy. The average effect also affects longevity.[31] Second, the provision of health care services directly competes with those of labour services allocated to the production and human capital sector. In other words, more health services lead to less human capital accumulation. Finally, health serves as a pre-request to the provision of human capital services. In this respect, health enters both in the utility and the production function. In particular, the generation of health services is defined by decreasing returns (Forster, 1989; Ehrlich and Chuma, 1990; Grossman, 1972) whereas human capital accumulation is modelled using constant returns to scale (the well-known knife-edge condition on the human capital accumulation dynamics). In this context, the social planner chooses the fractions that are respectively spent on human capital accumulation and health services production. This choice impacts on the average health level, and thus on the human capital accumulation, the production of the final good and the utility function. Two polar cases can be distinguished from this model. If the impact of the average health level on longevity is an externality, health becomes a pure complement to growth, *i.e.* any reallocation of labour from the health sector towards the human capital sector leads to a decline in growth. In contrast, if the impact of the average health level on longevity is internalised (as in their model), then increases in the demand for health services, as for instance caused by an ageing population, will adversely affect growth.

113. Other elements relating longevity, human capital and growth have been considered in the theoretical literature. Indeed, the expansion of life expectancy allows for higher returns to be obtained over a longer period of time and thus create incentives to invest more in education (Kalemli-Ozcan *et al.*, 2000; De la Croix and Licandro, 1999). In contrast, a reduction of life expectancy leads to higher competition for resources between the consumption and health needs of the elderly and the investment on education of the young population (Zhang *et al.*, 2003). In particular, Zhang *et al.* (2001) show that the effect of a life expectancy extension on long-run economic growth will depend on the utility parameters and the social security system. For instance, with a pay-as-you-go social security system, an increase in longevity will accelerate of parent's value on the welfare of their children and not the number of their children.

114. Confirming these theoretical arguments, on a worldwide level, better health, typically measured by life expectancy, appears as a significant determinant of a country's subsequent

31. Longevity being proportional to the average health level of the population.

economic growth, in some cases contributing even more than education (see Sala-i-Martin, Doppelhofer and Miller, 2004, Hongbin, Zhang and Zhang, 2007; López-Casanovas, Rivera and Currais, 2005). But this relation weakens in a sub-sample of rich countries.[32]

5.2 Does health contribute to growth in rich countries?

115. The effect of health and longevity is not so clear cut for developed countries. If non-active people are getting older and older through an increase of life expectancy, this will not expand the labour force nor the returns on investment in education or training. However, longevity also affects agents' willingness to substitute consumption over the life-cycle. Individuals with a higher life expectancy tend to be more patient and thus have higher levels of savings. *Ceteris paribus*, this should yield higher growth (Reinhart, 1999). Overall, life expectancy will affect growth via three different links: the saving decision, the labour market participation, and the competition for resources between the different activities. Therefore, there is no consensus about whether an increase of life horizon has a positive or a negative effect on growth, or simply does not affect it at all.

116. It could be noted that empirical studies often rely on poor proxies of health. The contribution of health is measured by life-expectancy, total health care expenditures, child mortality, or the mortality of some specific diseases. These explanatory variables often fail to capture the plausible pathways through which health may enhance growth through its effects on labour market participation, worker productivity, investment in R&D and human capital, savings and population age structure (Bloom and Canning, 2000; Bloom and Canning, and Sevilla, 2003; Easterlin, 1999).

117. In addition, the fact that the relation between health (or its proxies) and growth is weaker for developed countries could be due to a non-linear relationship, positive at low levels of development and insignificant or negative at higher levels. Bhargava *et al.* (2001) use adult survival rates (*i.e.*, the inverse of adult mortality rates) between ages 15 and 60 as a health proxy in order to assess the effect of health on economic growth in a worldwide panel data set for the period 1965 to 1990. Using an interaction term between the health proxy and per capita income, they detected a threshold income level beyond which adult survival rates have negligible or even negative effects on growth rates.

118. Using data from more than 50 developing and developed countries, Jamison *et al.* (2004), find that increases in physical capital stock dominate (accounting for 67% of total growth) but both educational improvements (14%) and health improvements (11%) make up for an important

32. It could be noted that disentangling the role of health in the context of standard growth regressions faces several general econometric challenges that have been highlighted in the literature (Pritchett, 2006; Rodrick, 2005; Sala-i-Martin, Doppelhofer, and Miller, 2004). In this context, recent papers have developed alternative approaches, for instance a macroeconomic production function model of growth (Bloom and Canning, 2005).

share, too. Most importantly, investment in health presents diminishing returns, consistent with the results reported by Bhargava (2001). These results require some qualifications. First, given lack morbidity or disability data, only mortality rates are used as a proxy for overall health conditions. However, it is plausible that changes in morbidity may also be significant for income growth while they are only partially correlated with mortality decline and they might lag mortality decline. Second, health improvements above the age of 60 (the threshold used in Bhargava *et al.*, 2001) may have an impact on retirement decision and may further improve even if the adult survival rate have already reached high levels.

119. Focusing on high-income countries, Knowles and Owen (1995) incorporated a proxy for health in the Mankiw, Romer and Weil's (MRW) empirical growth model. They examine a cross section of 84 countries for the period 1960 to 1985, using OLS estimates.[33] Their results suggest a stronger, more robust, relationship between *per capita* income and life expectancy, than between income and educational human capital. For a sub-sample of 22 high income countries, no statistically significant impact of life expectancy was found.

120. Rivera and Currais (1999a, 1999b, 2003) examine the impact of health in a cross-section of 24 high-income countries using an augmented Mankiw-Romer-Weil model.[34] In contrast to Knowles and Owen (1995), they use health expenditures as a proxy for health status, arguing that mortality rates represent a very limited indicator of the output of health care systems. Indeed, medical care is not exclusively or primarily aimed at influencing directly the probability of dying. In the absence of reliable time series data capturing both mortality and morbidity, the choice of health expenditures can not be dismissed. Both OLS and 2SLS estimates are carried out (using several instruments, such as alcohol consumption, rate of population over 65 years old, beds in-patient care per 1,000 population, etc). Results suggest a fairly robust positive impact of health (expenditures) on income. Following a similar approach, Gyimah-Brempong and Wilson (2004) and Beraldo *et al.* (2005) also found fairly, robust, statistical significant positive contribution of health expenditures on growth. The endogeneity of health expenditures to GDP per capita could nevertheless be a serious drawback in this type of studies.

121. Along these lines, recent contributions have focused more narrowly on the links between government health spending and growth. Agenor (2005) concentrates on the potential trade-off between health and other public services, such as education, security, and infrastructure services. The optimal allocation of government spending is determined in an endogenous growth model where public expenditure is an input in the production of final goods as well as health services. In his model health is treated as labour-augmenting and not as a separate factor of production. In particular, the amount of effective labour services provided by a worker is assumed to be proportional to his average health level. At the same time, health

33. The authors argue that (non-reported) 2SLS estimates gave qualitatively similar results. The 2SLS estimates use lagged values of potentially endogenous regressors - a strategy they acknowledge to be the natural choice in time series regressions but not in cross-country regressions.

34. These regressions are conducted over the years 1960-1990 in Rivera and Currais (1999a, 1999b), and for 1960-2000 in their 2003 article.

services enter in the household's utility function and thus affect directly the welfare. The specification of Agenor (2005) is close to the model proposed by Barro (1990), and thus do not display any transitional dynamics (reduced-AK model) when the flow of health services is considered. An increase of public spending on infrastructure increases growth both through an increase in infrastructure services to production and to health services. But it also reduces the resources allocated to health and hence leads to lower productivity and growth. The net effect is ambiguous and depends on the calibration of the parameters of the economy. When both the production and utility function depend on the stock of public capital in health, no general results can be derived.

122. In contrast, Aisa and Pueyo (2005, 2006) analyze the impact of government spending in a model of endogenous longevity. Aisa and Pueyo (2005) endogenise life expectancy by allowing the probability of survival to depend on health care public expenditures. Moreover, the accumulation of the health status depends on public health care expenditures as a percentage of income (Rivera and Currais, 1999).[35] Their model also follows Barro (1990). The production of final goods is obtained by combining private capital, labour and productive public services. Both public expenditures, which represent a constant fraction of GDP, are financed through taxes. Therefore, there is a trade-off between the amount of productive public services allocated to the production of final goods and the amount of health expenditures, which leads to a higher health status and thus increases the survival probability. Their theoretical results show that a higher life expectancy leads to a higher savings rate and to an expansion of the labour force (the labour participation effect). Depending on the parameters, these effects may enhance growth. But Aisa and Pueyo (2005) acknowledge that this effect is likely to be less clear cut in OECD countries, where efforts to increase life expectancy may have a negative effect on long-run growth. By modelling a non-monotonic effect of government spending on economic growth, Aisa and Pueyo (2006) obtain similar results. Public expenditures have two opposite effects. On the one hand, they reduce the impatience of consumers by lengthening life, which promotes saving and growth. On the other hand, resources devoted to health are at the expense of other factors, especially the accumulation of physical capital, which reduce growth. All in all, the effect of public expenditures is mixed.

123. Surrounding this type of empirical work, an important question is whether health care expenditures contribute to health outcomes. Echoing some of the results obtained at the micro or individual level presented in section 2, results appear particularly mixed when examining the relationship at the aggregate level. Earlier commentators have argued that the role of healthcare was rather small and may even have been detrimental (Illich 1976, McKeown 1979). In fact, the impact of "curative medical measures" may reasonably be assumed to have had little effect on mortality decline prior to the mid-20th century (Colgrove 2002). Since then, however, the scope and quality of healthcare have changed almost beyond recognition, but the debate about the relative role of health care continues.

35. They also assume a constant depreciation rate as in standard accumulation equations.

124. Explaining the mixed results obtained so far, Suhrcke and Urban (2006) argued that there is very little variation in life expectancy among rich countries (much in contrast to the wide variation among poor countries). They also share the view that the link between health expenditures and health outcomes is far too poorly understood for the former to serve as a proxy of the latter. For this reason, they use a health proxy that at least displays significantly greater variation among rich countries and is particularly characteristic of the health challenges that these countries are facing: the cardiovascular disease (CVD) mortality among the working age population. Starting from a worldwide sample of countries (acknowledging data problems on CVD data for low and middle income countries), they find that that the effect of working-age CVD mortality rates on growth was dependent on the level of initial per-person GDP. They therefore split the sample into (broadly defined) low- and middle-income countries, on the one hand, and high-income countries (26), on the other hand. Results were remarkably robust across different specifications and methods. In their preferred estimate, a 1% increase in the CVD mortality rate was found to decrease the growth rate of per-person income in the subsequent five years by about 0.1% in the high-income country sample.[36] While 0.1% is a small amount in growth terms, it is sizeable in absolute money terms when accumulated over many years. As an aside, the authors did not find a significant influence of CVD mortality on growth in the low- and middle-income country sample.

125. Weil (2005) uses three microeconomic indicators of health: average height of adult men, the adult survival rate for men and age of menarche for women. His preferred estimate leads to the conclusion that eliminating health differences among countries would reduce the variance of (log) per capita GDP by 9.9%. But this effect tends to be smaller than what is derived from cross-country regressions. Bloom and Canning (2005) compared the size of the microeconomic estimates of effect of health on wages with the macroeconomic estimates of the effect of health on worker productivity using a calibrated macroeconomic production function model. However, their database derived from the Penn World Tables also includes non-OECD countries, thus making difficult a comparison.

126. In sum, while the evidence on the impact of health care (and/or of health care expenditures) on health outcomes in rich countries remains mixed and estimates vary significantly subject to the selected method, there is still a fair amount of empirical support for the view that health care (expenditures) do matter for health outcomes. Not surprisingly, the evidence is far more solid when looking at the effects of specific interventions or treatments, such CVD or depression treatments, when compared to studies that examine aggregate relationships.[37]

---

36. The result is based on a panel of five-year intervals between 1960 and 2000, and includes a set of standard controls (including initial income, openness, secondary schooling, etc.). The authors used a dynamic panel growth regression framework, taking into account potential endogeneity problems from reverse causality or omitted variables, which might determine both CVD mortality and growth simultaneously.

37. For a survey on this area see Buck, Eastwood and Smith (1999).

127. Most importantly, the positive impact of improved health on economic growth has been in many countries prevented by a fixed and too low retirement age. Once institutional incentives for early retirement are lifted and the effective retirement age increases, through labour market participation of the elderly, the health status could have a more important role on growth.

5.2 Mechanical impact of ageing and individual productivity

128. A reason why the impact of health on growth may not appear as strong as it could be expected in the future is related to the question of productivity *level* vs. *growth* effects. Indeed, while health could be seen as a labour-augmenting factor increasing the level of individual productivity, its effect could not be sufficient to generate a growth enhancing mechanism. To see this point, we follow here a numerical simulation on the impact of ageing on productivity carried out by Oliveira Martins *et al*. (2005). They postulated different scenarios for the relation age between age and productivity, as displayed in Figure 5.1. It is commonly assumed that individual productivity follows a (quadratic) inverted U-shaped age profile (*e.g.* Miles, 1999). However, in a more optimistic age-productivity profile, productivity could stabilise after a certain age up to retirement. The impact of health care in this context could be envisaged as inducing, for example, a stabilisation in the health status at older ages that would prevent productivity to fall. The question is how much this would make a difference for aggregate productivity?

[Figure 5.1 Different age-productivity profiles]

129. The impact of each hypothetical individual age-productivity profile on aggregate productivity can be derived by applying them to population projections 2005-2050 used in this paper. Oliveira Martins *et al.* (2005) made this calculation for the US, Japan, Germany and France. Comparing the most optimistic scenario, assuming a flat productivity profile for old-age workers, with the more pessimistic one, where productivity declines steadily, shows a level difference; however, the order of magnitude of the change is small (+/-2.5%) and this level effect would stabilise relatively rapidly (Figure 5.2). Therefore it would hardly induce a significant growth effect. Notwithstanding, a better health could still help maintaining individual productivity levels, which combined with reforms that would create incentives and conditions for extending working lives, would still have a significant macroeconomic impact through labour force participation.

[Figure 5.2 Mechanical impact of ageing on productivity levels]

5.3 R&D, innovation and market structure in the health sector: Europe vs. the US

130. An important channel through which the health sector could influence growth is the R&D activities. Sanso and Aisa (2006) propose a model in which health is an engine of growth. More specifically, the biological deterioration rate—"the rate at which the effectiveness of health goods in maintaining a given level of health decreases as individual growth older"—is a key a parameter to determine the steady-state growth rate. In this respect, Sanso and Aisa (2006)

develop a dynamic general equilibrium model in which they integrate the accumulation of human capital, innovation in medical technology, health and longevity. In this framework, when agents decide on their "quantity" of life, the need to offset the biological deterioration rate encourages medical research, and thus growth, which permits in turn to finance medical research and health care expenditures.

131. In this perspective, the situation in the US contrasts with Europe. We will focus here on the pharmaceutical sector (for a description and analysis of the medical devices sector, see Pammolli *et al.* 2005). The US is increasingly outperforming Europe (and Japan) as the main player in medical innovation when looking at standard measures of R&D inputs (measured for instance by R&D expenditures) and outputs (measured for instance by patents and patent citations). The comparatively stronger emphasis in Europe on cost containment through its Social Security price and reimbursement regulations goes a long way in explaining these differences. This is what has arguably led to slower implementation of cost-enhancing technology in Europe. In the US, with very limited incentives for agents to consider the costs of treatment, there has accordingly been very limited incentive to invest in cost-reducing R&D. The EU health sector has therefore been in the position to take advantage of the development of new technologies elsewhere - chiefly the US - as it has been able to introduce them slowly, after the expensive early stages of implementation. While this has certainly contributed to lower average costs (at the expense of delay in implementation), it is hard to say what the effect on overall productivity in the EU has been. In evaluating the comparative performance of the different systems it is also important to take into account the trade-offs involved, for instance in terms of its effect on access to health care, which has become much skewed in the US case.

132. Before entering into the description of innovation outcomes of the pharmaceutical sector it is helpful to develop an idea of some basic characteristics of the market, and how they differ between the EU, the US and Japan. Overall, the pharmaceutical industry is a significant but nevertheless comparatively small sector of the economy. At the same time it displays a high level of productivity and is an exceptionally R&D intensive sector. The US market is not only the biggest but it has also been the fastest growing recently. In recent years the US pharmaceutical market, measured by sales at ex-factory prices, has grown faster than European markets (Table 5.1). The US market is currently twice as large as the EU-15 aggregate, and accounts for approximately 50% of the world market for pharmaceuticals (up from 31.2% in 1995). Europe held a 30% share of the global pharmaceutical market in 2003, while Japan's share in 2003 was nearly 12%. China, Brazil and India - not shown here - are growing fast, gaining shares in the international market (EC 2006).

[Table 5.1 The size of the Pharmaceutical markets (million Euros)]

5.3.1 A comparison of medical innovation input and output

133. Research and Development (R&D) is particularly important in the pharmaceutical industry. Despite data limitations and methodological problems, there have been some attempts

to measure pharmaceutical R&D expenditures (*e.g.*, Figure 5.3). The data shows an increase in R&D expenditures at least in Europe and the US, with the US overtaking Europe in recent years.

[Figure 5.3 Pharmaceutical R&D expenditure in Europe, the US and Japan (€ million, current prices and exchange rates)]

134. Although R&D expenditures have generally increased globally, the innovative output has declined over the past decades. This becomes for instance visible in the number of new chemical entities placed on the world market (Figure 5.4), indicating a decline in all three countries/regions. The Figure also shows that while the European pharmaceutical industry has for many years been the world's leading inventor of new medicines, over the past decade, the United States has become the dominant player, including R&D where Europe is under-represented in some crucial research fields such as biotechnology. Between 1960 and 1965, European companies invented 65% of new chemical entities (NCEs) placed on the world market. Forty years later their share had fallen to 34%. The latest data available (period 2001-2005) show the predominance of the United States which has now become the leading inventor of new molecules in the world.

[Figure 5.4 New chemical or biological entities]

135. The most widely used indicators in the empirical literature for the measurement of technological change are patents and of patent citations. Patents are a unique source of information about innovative activities, particularly in the pharmaceutical industry, where they play a prominent role in protecting returns from R&D. Table 5.2 represent all pharmaceutical and biotechnological patents granted from 1974 to 2003 by the United States Patent and Trademark Office (USPTO) to inventors and institutions located in the US, Japan, and the EU.

[Table 5.2 Shares of USPTO-granted pharmaceutical patents by countries on the nationality of the assignee and location of inventor]

136. Data indicate that the US is the main locus of innovative activities, and that its lead has grown over time. Table 5.2 shows that the majority of patents in biotechnology and pharmaceuticals are held by inventors located in the US. The number of pharmaceutical patents held by US-based inventors increased by 7 percentage points between 1984-1993 and 1994-2003. The increase is even more striking if we weight each patent by its importance, as approximated by the number of citations it receives (see Table 5.3).

[Table 5.3 Shares of patent citations of USPTO-granted pharmaceutical patents by countries based on the nationality of the assignee and location of the inventor]

137. Interestingly, the share of EU inventors is higher than the share of EU institutional assignees. The opposite is true for the US, even if the imbalance is gradually disappearing. In other words, there are more European inventors involved into research assigned to US

organizations and performing their research in the US than vice-versa, although the globalisation of R&D activities is gradually eroding this disparity.[38]

138. The US dominance appears even stronger when we consider patent citations data. In fact, Table 5.4 suggests that on average patents assigned to US institutions have a much greater impact on future innovative activity. US biopharmaceutical patents received 5.56 citations on average between 1994 and 2003, far more than European (2.92) and Japanese (2.07) ones. Furthermore, the largest share (almost half) of the European and Japanese citations go to US patents, although this finding must be interpreted with caution, since we are considering data on patents granted by the USPTO. Nevertheless, the trends in pattern of citations of the EU citing US and JP citing US reveal an increasing importance of US research for inventors located in Europe and Japan.

[Table 5.4: Patent citations]

5.3.2 Market structure characteristics explaining differences in innovative performance

139. There are significant differences in market structures between Europe and the US that are likely to affect incentives for R&D. Price differences between the US and EU-15 are accounted for entirely by differences in prices for branded drugs. In fact, prices of generic drugs in the US are substantially aligned with prices in the EU-15. In a few countries, such as Germany, generic prices are even higher than in the US. Price at entry for branded drugs is 43.4% higher in the US than average price in the market. The corresponding price gap in the EU-15 is 28.2%, and in Japan just 3.9%. US generic products, by contrast, are priced at 60.3% of the average prices in the market.

140. These price differentials between the US and Europe reflect radical differences in the extent of market regulation. Prices for branded drugs in countries with free or semi-regulated prices - such as the US and, to a lesser extent, UK and Germany - are higher than in countries where more direct forms of price regulation are in place, such as Italy and France. At the same time, the relatively unregulated markets tend to experience fierce price competition after patent expiry, since higher prices of branded drugs represent a strong incentive for generic entry and price competition à la Bertrand (Pammolli *et al.*, 2002; Magazzini *et al.* 2004). Generic penetration in terms of volume is much higher in the USA (33.7% of the market in 2004) and UK (31%) than in the average EU-15 (13.8%) and Japan (2.6%). The possibility to command substantially higher market prices for new and branded drugs can act as a powerful incentive for R&D and capital

38. It is important to note that in recent years, the number of patents in pharmaceuticals and biotechnology granted by the Chinese patent office has increased. The same applies to US patents granted to Chinese inventors. These increases indicate a process of accumulation of scientific and technological capabilities. India's recent performance in biopharmaceutical innovation, as reflected in patents granted, is similar to that of China. If these trends persist, China and India will strengthen their positions, becoming attractive and competitive destinations of foreign direct outward investment by multinational corporations (EC 2006).

investments that can explain, to a certain extent at least, the different trends characterising the EU and US pharmaceutical industries.

141. Overall, the US market is more concentrated than all the most important EU markets (Germany, France, Italy and Spain, but not the UK), as well as Japan, China and India. On average, the three leading products in each of 100 different therapeutic categories account for 85.6% of total market share in the US, as compared with a total market share of 76.5% in the EU-25. It is clear that European markets are much more fragmented than the US market. The US market is as concentrated as the European one in terms of volume, while it is the most concentrated in terms of sales. To a large extent, the high concentration of the US market is due to the "premium price" that best-in-class products can command. Indeed, the relative price of the market leader in the US is 44% higher than the market average price - more than in Europe (22%) and Japan (15%).

142. Higher concentration in the US market does not imply less competition, however. On the contrary, firm turnover in the US is almost double that of the EU-15 and EU-25. The "premium price" for new innovative drugs tends to induce higher levels of industrial concentration in the US. The lower turnover of EU markets translates into a higher persistency and a lower contestability of the leading products. The US average persistency of the leading product is slightly less than 6 years, while in the EU it is almost 10 years and in Japan more than 15 years

143. The US market has also the highest product turnover. The US rate is 59.5% higher than EU-15, and 38.8% higher than Japan. The most striking difference is found in product exit rate, which is on average 77.2% higher in the US than in the EU-15, and 40.7 higher than in Japan. Product entry rates are 51.3% higher in the US than in the EU-15, and 38.8% higher than in Japan. Therefore, the process of creative destruction is much more intense in the US market than in European or Japanese markets.

144. All in all, the US pharmaceutical market seems highly contestable; product turnover is much more frequent than in the EU and Japan; and competition from generic producers is substantial. US market behaviour is consistent with that of a market characterized by Schumpeterian competition, where innovators can gain temporary quasi-monopoly profits, which in turn spur innovation efforts by competitors that quickly leads to more innovative products and a high turnover of market shares. Dynamic competition is less evident in the EU as a whole, and especially in certain continental European countries. As documented extensively in Gambardella, Orsenigo and Pammolli (2000), there is too little market-based competition in some of the European countries, resulting in a less-efficient industry, as reflected in productivity indicators and market performance.

6. Summary and policy discussion

145. Since human capital is the main driver of productivity and growth in knowledge-based economies, health should also matter for economic outcomes. In the context of rapid population

ageing, the contribution of health for human capital and hence for growth potential could therefore be expected to become increasingly important. This paper tackled this issue by offering an integrated view of the relationships between, health spending, medical innovation and adoption, health status, growth and welfare.

146. We started with the observation that longevity has increased steadily in developed countries. Providing labour market and pension reforms offer the right environment, we showed that these longevity gains could be used to smooth the negative effects of baby-boom bust on labour force, notably in Europe. A key condition, however, is the existence of a virtuous cycle between longevity and health status (so-called "healthy ageing"). Despite the uncertainties on whether healthy ageing could continue in the future, improved health status can be (and has been) achieved to a significant extent through improved health care. The evidence reviewed here, suggests that the value attributed to the resulting reduction in mortality and/or morbidity, at least for specific interventions or treatments, most often exceed the costs and thus has been a worthwhile investment.

147. But health care is costly and developed societies are spending an increasing share of their income in health services and products, with already strained public budgets paying most of the bill. This rising expenditure trend has little relation to demography, but it is rather driven by consumers' preferences for longer lives and the diffusion of technological progress. We provided empirical evidence that health expenditures tend to grow in line with incomes (unitary income elasticity); on the top of this income effect, it is the change in medical practices that explains most of the drift of health expenditures per capita.

148. The structure of health insurance, as well as the regulation of health care supply might also encourage some costly innovations with a small benefit in terms of social welfare. Prevention policies should also be considered in this regard. The paper focused on curative treatments, adopting a somewhat narrow perspective of “health investment”. The potential for (especially primary) prevention – through the health care system or beyond – to improve health and thereby perhaps even to alleviate the future health expenditures burden is still a matter of some debate (Fries, Koop, Sokolov *et al.* 1998; Harvey 1998). While more work to clarify the potential health and fiscal benefits from prevention is clearly warranted, the value of non-clinical prevention may even become more important in the future, given the already big and rising challenge of obesity affecting essentially all rich countries (and not only).

149. Policies have to define the limit between the package of health care services which are covered through a mandatory health insurance (public or private and regulated through a managed competition scheme), and the other services which will be covered by a free private voluntary insurance. In each country, a fine tuning should allow to take into account social preferences relative to the pace of technological progress, equity in access to innovations and tax burden.

150. Given the various determinants of health expenditures, we carried out several projection exercises leading to the conclusion that the expected increase in the resources directed to health care by 2050 is substantial (ranging from 4 percentage points in a conservative scenario to above 12 percentage points of GDP). The question then arose on what could be the likely impact of these developments on economic growth, and what could be the impact, if longevity was "better managed"? In particular, would there be a role for investing in health to act as a driver of the European catching up with the US in terms of GDP per capita?

151. Despite convincing theoretical arguments, the empirical evidence reviewed in this paper on the impact of health and health spending on economic growth in rich countries is rather mixed. Probably, the positive impact of improved health on the economy has been hindered by a fixed and too low retirement age. Once institutional incentives for early retirement are lifted and the effective retirement age increases, through labour market participation of the elderly, the health status could have a more important role on growth. It may seem a bit paradoxical that Europe is doing better than the US in terms of life expectancy, but is falling to capitalise on these additional human resources by having early retirement and long inactive lives. Simple numerical simulations support the view that the labour market participation effect is likely to be more important than a hypothetical increase in the individual level of productivity associated with a better health status.

152. Finally, given the role of preferences and the demographic transition, the global market for health services and products is huge. Satisfying this demand offers a potential for growth, but the EU is lagging behind the US in terms of health-related R&D and innovation. This is partly due to differences in regulation and market structure, which would require appropriate product market reforms. In this context, ageing countries could take advantage of longevity and develop goods and services targeted to the older segments of the population. This would build new dynamic comparative advantages, reinforced by fast technical progress in biotech sectors. Overall, health policies are connected and are often complementary with other areas (e.g. public budgets, labour market, pensions, etc.), so reforms need to be broad-based.

REFERENCES

Abel-Smith, B. (1967), "An International Study of Health Expenditure", *Public Health Papers* No.32, WHO, Geneva.

Agenor, P.R. (2005), "Health and Infrastructure in Models of Endogenous Growth", *Center for Growth and Business Cycle Research Discussion Paper Series*.

Aghion, P. and P. Howitt (1992), "A Model of Growth Through Creative Destruction", *Econometrica*, vol. 51, pp. 323-351.

Aghion, P. and P. Howitt (1998), *Endogenous Growth Theory*, Cambridge, MA, MIT Press.

Auerbach A., L.Kotlikoff (1987), Dynamic fiscal policy, Cambridge University Press.

AHCPR (1997), *Trends in Personal Health Care Expenditures, Health Insurance and Payment Sources, Community Based Population, 1987-1995*, Agency for Health Care Policy and Research, Center for Cost and Financing Studies, National Medical Survey Data, March 1997, Table 8.

Aisa, R., and F. Pueyo (2004), "Endogenous Longevity, Health and Economic Growth: A Slow Growth for a Longer Life", *Economics Bulletin*, vol. 9(3), pp. 1-10.

Aisa, R., and F. Pueyo (2006), "Government Health Spending and Growth in a Model of Endogenous Longevity", *Economics Letters*, vol. 90, pp. 249-253.

Aprile, R. (2004), "How to Take Account of Death-Related Costs in Projecting Health Care Expenditure – Updated Version", *mimeo*, Ragioneria Generale Dello Stato.

Ashenfelter, O. and M. Greenstone (2004), "Using Mandated Speed Limits to Measure the Value of a Statistical Life", *Journal of Political Economy*, February, 112(1), S226-S267, Part 2.

Baker and Brown, M.E. Chernew *et al.* (1999), "The Effect of Managed Care on Health Care Providers", *RAND Journal of Economics,* Summer, 351-374.

Baltagi, B.H. (2005), *Econometric Analysis of Panel Data*, John Wiley & Sons, Third Edition.

Barro, R.J. (1990), "Government Spending in a Simple Model of Endogenous Growth Model", *Journal of Political Economy*, vol. 98, S103-S125.

Barros, P.P. (1998), "The Black Box of Health Care Expenditure Growth Determinants", *Health Economics* 7, 538-544.

Baumol, W.J. (1967), "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis", *American Economic Review* 57: 415-426.

Baumol, W.J. (1993), "Health Care, Education and the Cost of Disease: A Looming Crisis for Public Choice," *Public Choice* 77:17-28.

Bech, M. *et al.* (2006), "How do Economic Incentives and Regulatory Factors Influence Adoption of New Medical Technologies? Result from the TECH Project".

Bentzen, J. (2005), "Testing for Catching-up Periods in Time Series Convergence", *Economic Letters*, 88, 323-328.

Beraldo, S., Montolio, D. and Turati, G. (2005), "Healthy, educated and wealthy: is the welfare state really harmful for growth?", Espai de Recerca en Economia *Universitat de Barcelona Working Papers in Economics* no. 127.

Berndt *et al.* (2000), "The Medical Treatment of Depression, 1991-1996: Productive Inefficiency, Expected Outcome Variations, and Price Indexes", *NBER Working Paper* No.7816.

Bhargava, A., Jamison, D.T., Lau, L.J. and Murray, C.J.L. (2001) "Modeling the effects of health on economic growth." *Journal of Health Economics*, 20, 423-440.

Blomqvist, A.G. and R.A.L. Carter (1997), "Is health care really a luxury?", *Journal of Health Economics* 16 2, pp.207–230.

Bloom D., Canning D and J. Sevilla (2003). "Longevity and life cycle savings", *Scandinavian Journal of Economics*, 105:319–338.

Bloom D., D. Canning (2005), "Health and economic growth: reconciling the micro and macro evidence", *mimeo*.

Bloom D.., D. Canning (2000), "The Health and Wealth of Nations", *Science*, Vol. 287. no. 5456, pp. 1207 – 1209.

Börsch-Supan, A. *et al.* (2005), *Health, Ageing and Retirement in Europe: First results from the Survey of Health, Ageing and Retirement in Europe*, Manheim Research Institute for the Economics of Ageing, Manheim.

Börsch-Supan, A., A. Ludwig and J. Winter (2002), "Ageing, pension reform and capital flows", in A. Auerbach and H. Hermann (eds.), *Ageing, Financial Markets and Monetary Policy*, Heidelberg: Springer, pp. 55–83.

Börsch-Supan, A., A. Ludwig and J. Winter (2006), "Ageing, Pension Reform and Capital Flows: A Multi-Country Simulation Model", *Economica* 73, 625–658

Bots M.L, Grobbee D.E. (1996), Decline of coronary heart disease mortality in The Netherlands from 1978 to 1985: contribution of medical care and changes over time in presence of major cardiovascular risk factors. *J Cardiovasc Risk*. 1996 Jun;3(3):271-6.

Bunker, J.P. (2001), "The role of medical care in contributing to health improvements within societies", *International Journal of Epidemiology*, 30 (6), pp. 1260-1263(4)

Bunker, J.P., Frazier H.S., Mosteller F. (1994), "Improving health: measuring effects of medical care",. *Milbank Mem Fund Quart* ; 72:225-58.

Burniaux, J.-M., R. Duval and F. Jaumotte (2003), "Coping with Ageing: a Dynamic Approach to Quantify the Impact of Alternative Policy Options on Future Labour Supply in OECD Countries", *OECD Economics Department Working Papers* No. 371.

Buck D, Eastwood A, Smith P. (199), "Can we measure the social importance of health care?", *International Journal of Technology Assessment in Health Care* 15(1):89-107.

Canova, F. (2007), *Applied Macroeconomic Research*, Princeton University Press.

Capewell, S., Morrison C.E., McMurray J.J. (1999), "Contribution of modern cardiovascular treatment and risk factor changes to the decline in coronary heart disease mortality in Scotland between 1975 and 1994". *Heart* 81:380-6.

Cheung, S. L. J.M. Robine (2007), "Increase in longevity and the compression of mortality: the case of Japan". *Population Studies*, vol. 61, no. 1, pp. 85-97.

Conti *et al.* (2006), "Early Retirement and Public Disability Insurance Applications: Exploring the Impact of Depression", *NBER Working Paper* 12237.

Cullis J.G., West, P.A., 1979, *The Economics of Health, an Introduction*, Martin Robertson, London.

Culyer, A. (1988), "Health Care Expenditures in Canada: Myth and Reality; Past and Future", *Canadian Tax Paper* No.82, Canadian Tax Foundation, Toronto.

Culyer, A.J. (1990), "Cost Containment in Europe", *Health Care Systems in Transition*, OECD, Paris.

Cutler D.M., Rosen A.B., Vijan S. (2006), "The Value of Medical Spending in the United States, 1960 –2000". *New England Journal of Medicine,* 355:920-7.

Cutler, D. (2004), "Your Money or your Life: Strong Medicine for America's Health Care System", *Oxford University Press*, New York.

Cutler, D. and M. McClellan (2001), "Is Technological Change in Medicine Worth It?", *Health Affairs,* XX, 11-29.

Cutler, D., A.S. Deaton and A. Lieras-Muner (2006), "The Determinants of Mortality", *Journal of Economic Perspectives,* XX, 97-120.

Cutler, D., M. McClellan (1996), "The Determinants of Technological Change in Heart Attack Treatment", *NBER Working Paper* No. 5751.

Cutler, D., M. McClellan, J.P. Newhouse, D. Remler (1998), "Are Medical Prices Falling?" *Quarterly Journal of Economics* 113(4): 991-1024.

Dang, T.T., P. Antolin and H. Oxley (2001), "Fiscal Implications Ageing: Projections of Age-Related Spending", OECD *Economics Department Working Papers* No.305, Paris.

De La Croix, D. and O. Licandro (1999), "Life Expectancy and Endogenous Growth", *Economic Letters*, vol. 65, pp. 255-263.

Di Matteo, L. and R. Di Matteo (1998), "Evidence on the determinants of Canadian provincial government health expenditures: 1965–1991", *Journal of Health Economics* 17, pp.211–228.

Docteur, E. and H. Oxley (2003), "Health-care systems: lessons from the reform experience", *OECD Economics Department Working Papers* No. 374.

Dormont, B. M. Grignon and H. Huber (2005), "Health Expenditures and the demographic rethoric: reassessing the threat", *Institute of Health Economics and Management Working Paper* no. 05-01, Lausanne.

Dormont, B. and Milcent (2006), "Innovation Diffusion Under Budget Constraints. Micro-econometric Evidence on Heart Attack in France", Annals of *Economics and Statistics* No.79/80.

Dormont, B., M. Grignon, H. Huber (2006), "Health Expenditure Growth : Reassessing the Threat of Ageing", *Health Economics,* Vol.15, 9, 947-963.

Dreger, C. and H.-E. Reimers (2005), "Health Care Expenditures in OECD Countries: A panel Unit Root and Cointegration Analysis", *IZA Discussion Paper* 1469, Bonn.

Duval, R. (2003), "The Retirement Effects Of Old-Age Pension And Early Retirement Schemes In OECD countries", OECD Economics Department Working Papers no.370

Easterlin (1999), "How Beneficent is the Market? A Look at the Modern History of Mortality," *European Review of Economic History*, December, 1999, 3:3, 257-294.

EC-Economic Policy Committee (2001), *Budgetary Challenges Posed by Ageing Populations: The Impact on Public Spending on Pensions, Health and Long-term Care for the Elderly and Possible Indicators of the Long-term Sustainability of Public Finances,* EPC/ECFIN/655/01-EN final, October.

EC- Economic Policy Committee (2005), "The 2005 EPC Projection of age-related expenditure: Agreed underlying assumptions and projection methodologies", *European Economy*, Occasional Papers no. 19.

EC-European Commission (2006), *European Competitiveness Report 2006*, Brussels.

EFPIA (2006), *The Pharmaceutical Industry in Figures*, The European Federation of Pharmaceutical Industries and Associations, Brussels.

Englert, M. (2004), "Assessing the Budgetary Cost of Ageing and Projecting Health Care (+ Care for Elderly) Expenditure: The Belgian experience", Federal Planning Bureau, Brussels.

Erlich, I., and H. Chuma (1990), ''A Model of the Demand for Longevity and the Value of Life Extension'', *Journal of Political Economy*, vol. 98, pp. 760-782.

Fisher, F.M. and K. Shell (1972), "*The Economic Theory of Price Indices",* New York Academic Press.

Fogel, R. (2003), in "*Changes in the Process of Aging During the Twentieth Century: Findings and Procedures of the Early Indicators Project", NBER Working Paper* No.9941.

Fogel, R. (2003), "Changes in the Process of Aging During the Twentieth Century: Findings and Procedures of the Early Indicators Project", *NBER Working Paper* 9941.

Forster, B.A. (1989), ''Optimal Health Investment Strategies'', *Bulletin of Economic Research*, vol. 41, pp. 45-57.

Freedman, Martin and Schoeni (2002), Recent Trends in Disability and Functioning Among Older Americans: A Systematic Review. *Journal of the American Medical Association* 288: 3137 - 3146.

Fries, J.F. (1980), "Ageing, natural death, and the compression of morbidity", *New England Journal of Medicine* 303: 130-135.

Fries, J.F., C.E. Koop, J. Sokolov, C.E. Beadle and D. Wright (1998), "Beyond health promotion: Reducing need and demand for medical care", *Health Affairs* 17(2): 70–84.

Fuchs, V. (1984), "Though Much is Taken: Reflections on Ageing, Health and Medical Care", *NBER Working Paper* No.1269.

Galasso, V. (2006), *The Political Future of Social Security in Aging Societies*, MIT Press, Massuchets.

Gambardella A., L. Orsenigo and F. Pammolli (2000), "Global Competitiveness in Pharmaceuticals: A European Perspective", European Commission, November.

Gelijns, A. and N. Rosenberg (1994), "The Dynamics of Technological Change in Medicine", *Health Affairs,* Summer, pp.29-46.

Gerdtham, U., J. Sogaard., F. Anderson and B. Jonsson (1992), "An Econometric Analysis of Health Care Expenditure: A Cross-Section Study of the OECD Countries", *Journal of Health Economics*, Vol.11, No.1, pp.63-84.

Gerdtham, UG, B. Jonsson, M. MacFarlan, H. Oxley (1998), "The Determinants of Health Expenditure in the OECD Countries: A Pooled Data Analysis", *Health, the Medical Profession and Regulation*, Kluwer Academic Publisher, Dordrecht, 113-134.

Getzen, T. (1990), "Macro Forecasting of National Health Expenditures", in: Rossiter, L.and R. Scheffler (eds.), *Advances in Health Economics*, Vol.11, pp.27–48.

Getzen, T. (2000), "Health Care is an Individual Necessity and a National Luxury: Applying Multilevel Decision Models to the Analysis of Health Care Expenditure", *Journal of Health Economics* 19, pp.259-270.

Getzen, T.E. (1992), "Population Ageing and the Growth of Health Care Expenditures", *Journal of Gerontology*, 47: S98-S104.

Goldman *et al.* (2005), "Consequences of Health Trends and Medical Innovation for the Future Elderly", *Health Affairs*, W5-R5.

Gray, A. (2004), *Estimating the impact of ageing populations on future health expenditures*, Public lecture to the National Institute of Economics and Business and the National Institute of Health and Human Science, 4 November, Canberra.

Griliches, Z., ed. (1971), *"Price Indexes and Quality Change"*, Harvard University Press, Cambridge, MA.

Grossman, M. (1972), "On the Concept of Health Capital and the Demand for Health", *Journal of Political Economy*, vol. 80, pp. 223-255.

Grossman, M. (1998), "On Optimal Length of Life", *Journal of Health Economics*, vol. 17., pp. 499-509.

Grunenberg, E.M. (1977), "The failure of success", *Milbank Memorial Fund Q. Health Soc*. 55: 3-24.

Gyimah-Brempong K. and M. Wilson (2004), "Health human capital and economic growth in Sub-Saharan African and OECD countries", *The Quarterly Review of Economics and Finance* 44(2):296-320.

Hall R. and Jones C. (2007), " The Value of Life and the Rise in Health Spending », The Quarterly Journal of Economics, Feb. 2007", pp. 39-72.

Harvey K. (1998), "Health promotion is a waste of time and money". *British Medical Journal* 317(7162): 887.

Hitiris, T. and J. Posnett (1992), "The determinants and effects of health expenditure in developed countries", *Journal of Health Economics*, Vol. 11, No. 2, pp.173-81.

Hongbin, L., J. Zhang and J.Zhang (2007), "Effects of longevity and dependency rates on saving and growth: Evidence from a panel of cross countries", *Journal of Development Economics* 84: 138–154.

Howitt, P. (2005), "Health, Human Capital, and Economic Growth: A Schumpeterian Perspective", *mimeo*.

Hunink M.G., Goldman L., Tosteson A.N., *et al.* (1997), "The recent decline in mortality from coronary heart disease, 1980-1990: the effect of secular trends in risk factors and treatment", *JAMA*, 277:535-42.

Ingenue (2001), "Macroeconomic Consequences of Pension Reformsin Europe: An Investigation with the INGENUE World Model", *CEPII Working Papers* no. 17.

Jacobzone, S. (2003), "Ageing and the Challenges of New Technologies: Can OECD Social and Health Care Systems Provide for the Future? ", *The Geneva Papers on Risk and Insurance*, Vol. 28, No. 2, April, pp.254-74.

Jamison D. *et al.* (2004), "Health´s contribution to economic growth in an environment of partially endogenous technological progress", *Disease Control Priorities Project Working Paper* No. 10.

Jones, C.I. (2004), "Why Have Health Expenditures as a Share of GDP Risen So Much?", U.C. Berkeley, Working paper.

Jönsson, B. and I. Eckerlund (2003), "Why do different countries spend different amounts on health care?", *A Disease-based Comparison of Health Systems*, OECD, Paris.

Kalemli-Ozcan, S, Ryder, H.E. and D.N. Weil (2000), "Mortality Decline, Human Capital Investment and Economic Growth", *Journal of Development Economics*, vol. 62, pp. 1-23.

Kleiman, E. (1974), "The Determinants of National Outlay on Health", in: Perlman, M. (Ed.), *The Economics of Health and Medical Care*, Macmillan, London.

Knowles, S. and Owen, P. (1995), "Health capital in cross-country variation in income per capita in the Mankin-Romer-Weil model", *Economic Letters*, 48: 99–106.

Leu, R.E. (1986), "The Public-Private Mix and International Health Care Costs. *Public and Private Health Services: Complementarities and Conflicts.* Blackwell Scientific Publications, Oxford, 41-63.

Levine R, Renelt D (1992), "A sensitivity analysis of cross-country growth regressions", *American Economic Review*, 80:942–963.

Lichtenberg, F.R. (2003), "The Impact of New Drug Launches on Longevity: Evidence From Longitudinal, Disease-Level Data From 52 Countries, 1982-2001", *NBER Working Paper Series* No. 9754.

López-Casanovas, G., B. Rivera and L. Currais (2005), *Health and Economic Growth*, MIT Press, Cambridge, Massachusetts.

Lubitz, J.B. (2005), "Health, Technology, and Medical Care Spending", *Health Affairs*, W5 -R 81.

Lubitz, J.B., G.F. Riley (1993), "Trends in Medicare Payments in the Last Year of Life", *New England Journal of Medicine* 328: 1092-1096.

Lucas, R.E. (1988) "On the Mechanisms of Economic Development", *Journal of Monetary Economics*, vol. 22, pp. 3-42.

Luce, B.R., Mauskopf J., Sloan F.A., Ostermann J., Paramore L.C., (2006), "The return on investment in health care: from 1980 to 2000", *Value Health* May-Jun;9(3):146-56.

Magazzini L., F. Pammolli, M. Riccaboni (2004), "Dynamic Competition in Pharmaceuticals: On Patent Expiry, Generic Penetration and Industry Structure", *European Journal of Health Economics*, 5, 175-182.

Manning, W. *et al.* (1987), "Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment", *American Economic Review* 77, pp.251–277.

Maxwell, R. (1981), *Health and Wealth: An International Study of Health Care Spending*, Lexington Books, MA.

McClellan, M.B. and D.B. Kessler for the TECH investigators (1999), "A Global Analysis of Technological Change in Health Care: The Case of Heart Attacks", *Health Affairs* 18(3):200-255.

McClellan, M.B. and D.B. Kessler, eds. (2002), "*Technological Change in Health Care. A Global Analysis of Heart Attack".* The University of Michigan Press.

Michel, J.-P. and J.-M. Robine (2004), "A 'New' General Theory of Population Ageing", *The Geneva Papers on Risk and Insurance* Vol. 29 No. 4 (October), pp.667–678.

Miles, D. (1999), "Modelling the Impact of Demographic Change Upon the Economy", *The Economic Journal*, Vol. 109 no. 452.

Moise, P. and S. Jacobzone (2003), "Population Ageing, Health Expenditure and Treatment: an ARD Perspective", *A Disease-based Comparison of Health Systems*, OECD, Paris.

Murphy, K. and R. H. Topel (2006), "The value of Life and Longevity", *Journal of Political Economy*, 2006, Vol. 114, n°5.

Nahar, S. and B. Inder (2002), "Testing convergence in Economic Growth for OECD countries", *Applied Economics*, 34, 2011-2022.

Narayan, P.K. (2007), "Do Health Expenditures 'Catch-up'? Evidence from OECD Countries", *Health Economics*, in press.

Newhouse (1992), "Medical Care Costs: How Much Welfare Loss?", *Journal of Economic Perspectives*, Vol. 6, No. 3, pp.3-21.

Newhouse, J.P. (1977), "Medical Care Expenditure: A Cross-National Survey", *Journal of Human Ressources*, 12, 115-125.

Newhouse, J.P. (1987), "Cross-National Differences in Health Spending: What do they Mean?", *Journal of Health Economics*, 6, 159-162.

Newhouse, J.P. and C.E. Phelps (1976), "New Estimates of Price and Income Elasticities of Medical Care Services", in: Rosett, R.N. (Ed.), *The Role of Health Insurance in the Health Services Sector*, NBER, New York.

Norton, E.C. (2000), "Long-Term Care", in Culyer, A.J. and J.P. Newhouse (eds.), *Handbook of Health Economics*, Vol.1B, Elsevier, North-Holland.

O'Connell, J. (1996), "The Relationship Between Health Expenditures and the Age Structure of the Population in OECD Countries", *Health Econ.* 5: 573-578.

OECD (1987), *"Financing and Delivering Health Care: A Comparative Analysis of OECD Countries"*, OECD Social Policy Studies, 4.

OECD (2005a), *Health Database,* Paris.

OECD (2005b), *Long-term Care for Older People*, Paris.

OECD (2006), "Projecting OECD Health and Long-Term Care Expenditures: What are the Main Drivers?", *OECD Economics Department Working Papers* no. 477.

OEPPEN, J., et J. W. VAUPEL (2002), "Broken limits to life expectancy", Science, 296, 5570 : 1029-1031

Okuande, A.A. and V.N.R. Murthy (2002), "Technology as a Major Driver of Health Costs: A Cointegration Analysis of the Newhouse Conjecture", *Journal of Health Economics* 21, pp.147-159.

Okunade, A.A. and M. Karakus (2001), "Unit Root and Cointegration Tests: Time Series versus Panel Estimates for International Health Expenditures", *Applied Economics*, 33, 1131-1137.

Oliveira Martins, J. and F. Pelgrin (2007), "Health care expenditures and GDP: an overview", *mimeo*.

Oliveira Martins, J. and C. de la Maisonneuve (2006), "The Drivers of Public Expenditure on Health and Long-Term Care: an Integrated Approach", *OECD Economic Studies* no. 43/2.

Oliveira Martins, J., F. Gonand, P. Antolin, C. de la Maisonneuve and K. Yoo (2005), "The Impact of Ageing in Demand, Factor Markets and Growth", *OECD Economics Department Working Papers* No. 420.

Olshansky, J. et al. (2005), "A potential decline in Life Expectancy in the United States in the 21st Century", *The New England Journal of Medicine*, 352:11, pp. 1138-1145.

Pammolli F. *et al.* (2005), "Medical devices: competitiveness and impact on public health expenditures", study prepared for the European Commission-Directorate Enterprise and Industry. July.

Pammolli F., L. Magazzini, L. Orsenigo (2002), "The Intensity of Competition after Patent Expiry in Pharmaceuticals: A Cross-Country Analysis", *Revue d'Economie Industrielle*, 99, 107-132.

Parker, S. and R. Wong (1997), "Household Income and Health Care Expenditures in Mexico", *Health Policy* 40, pp.237–255.

Pesaran, H., R.P.Smith and K.S.Im, Dynamic Linear Models for Heterogenous Panels, in *The Econometrics of Panel Data* (eds) L. Mátyás and P. Sevestre, 1996, chapter 8, pp.145-195, Kluwer Academic Publishers.

Phillips, P.C.B. and D. Sul (2007), "Transition Modeling and Econometric Convergence Tests", *Cowles Foundation Discussion Paper* No. 1595.

Pritchett L. (2006). "The quest continues", *Finance and Development* March: 18–22.

Productivity Commission (2005a), *Economic Implications of an Ageing Australia*, Research Report, Canberra.

Productivity Commission (2005b), *Impacts of Medical Technology in Australia*, Progress Report, Melbourne, April.

Reinhart, V.R. (1999), "Death and Taxes: Their Implications for Endogenous Growth", *Economic Letters*, vol. 92, pp. 339-345.

Richardson, J. and I. Robertson (1999), "Ageing and the Cost of Health Services", in *Policy Implications of the Ageing of Australia's Population*, Productivity Commission and Melbourne Institute, Canberra.

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

Rivera, B. and Currais, L. (1999b), "Income variation and health expenditure: evidence for OECD countries", *Review of Development Economics* 3(3): 258–267.

Rivera, B., and L. Currais (1999), "Income Variation and Health: Direct Impact or Reverse Causation", *Applied Economics Letters*, vol. 92, pp. 339-345.

Robine, J.M. and J.P. Michel (2004), "Looking Forward to a General Theory on Population Aging", *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences* 59:M590-M597.

Rodrik D. (2005)., "*Why We Learn Nothing from Regressing Economic Growth on Policies*", Harvard University, mimeo.

Sala-i-Martin X., Doppelhofer G., Miller R., (2004). "Determinants of long-term growth: a Bayesian averaging of classical estimates (BACE) approach", *The American Economic Review*, 94:813–835.

Sanso, M., and R., Aisa (2006), "Endogenous Longevity, Biological Deterioration, and Economic Growth", *Journal of Health Economics*, vol. 25, pp. 555-578.

Seshamani, M., A.M. Gray (2004), "A Longitudinal Study of the Effects of Age and Time to Death on Hospital Costs", *Journal of Health Economics.* 23 (2) 217-235.

Seshamani, M., A.M. Gray (2004), "Aging and Health-Care Expenditure: the Red Herring Argument Revisited", *Health Economics* 13: 303-314.

Shapiro *et al.* (2001), "Measuring the Value of Cataract Surgery", in *Medical Care Output and Productivity*, ed. Cutler and Berndt.

Stearns, S.C., E.C. Norton (2004), "Time to Include Time to Death? The Future of Health Care Expenditure Predictions", *Health Econ.* 13: 315-327.

Sturm, R. and D. Lakdawalla (2004), "Swollen Waistlines, Swollen Costs. Obesity Worsens Disabilities and Weighs on Health Budgets", *RAND Review*, Spring, 2004.

Suhrcke, M. and D. Urban (2006), "Are cardiovascular diseases bad for economic growth?", *CESifo Working paper* no. 1845.

Sunshine, J.H. and M. Dicker (1987), "Total Family Expenditures for Health Care, United States, 1980", *National Medical Care Utilization and Expenditure Survey, Series B, Report No. 15, DHHS pub No. 87-20215*, National Center for Health Statistics, Public Health Service, Washington, DC, U.S. Government Printing Office.

The Technological Change in Health Care (TECH) Research Network (2001), "Technological Change around the World: Evidence from Heart Attack Care", *Health Affairs* 20(3): 25-42.

Triplett, J.E. and B.P. Bosworth (2000) , "Productivity in the Services Sector", Brookings Institution, *mimeo*.

Unal, B., Critchley J.A., Capewell S. and Modelling (2005), "The decline in coronary heart disease deaths in England and Wales, 1981-2000: comparing contributions from primary prevention and secondary prevention", *BMJ*, 331:614.

Van Zon, A., and J. Muysken (2001), "Health and Endogenous Growth", *Journal of Health Economics*, vol. 20, pp. 169-185.

Viscusi, W. and J. Aldy (2003), "The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World", *Journal of Risk and Uncertainty*, 27, 5-76.

Wagstaff, A., E. van Doorslaer and P. Paci (1991), "Equity in the Finance and Delivery of Health Care: Some Tentative Cross-Country Comparisons", in: McGuire, A., P. Fenn, and K. Mayhew (Eds.), *Providing Health Care*, Oxford, 1991.

Weisbrod, B.A. (1991), "The Health Care Quadrilemma: An Essay on Technological Change, Insurance, Quality of Care, and Cost Containment", *Journal of Economic Literature* 29, 523-555.

Werblow, A., S. Felder, P. Zweifel (2007), "Population Ageing and Health Expenditure: A School of "Red Herring""?, *Health Economics*, forthcoming.

Westerhout, E. and F. Pellikaan (2005), "Can We Afford to Live Longer in Better Health?", *Netherlands Bureau for Economic Policy Analysis*, Document No. 85, June.

Yang, Z., E.C. Norton, S.C. Stearns (2003), "The Real Reasons Older People Spend More", *Journal of Gerontology Science* 58B(1): S1-S10.

Zhang, J., and J. Zhang (2001), "Longevity amd Economic Growth in a Dynastoc Family Model with an Annuity Market", *Economics Letters*, vol. 72, pp. 269-277.

Zhang, J., Zhang, J., and R. Lee (2001), "Mortality Decline and Long-run Economic Growth", *Journal of Public Economics*, vol. 80, pp. 485-507.

Zhang, J., Zhang, J., and R. Lee (2003), "Rising Longevity, Education, Savings, and Growth", *Journal of Development Economics*, vol. 70, pp. 103-117.

Zweifel, P., S. Felder, A. Werblow (2004), "Population Aging and Health Care Expenditures: New Evidence on the Red Herring". *The Geneva Papers on Risk and Insurance*, vol.29(49), October.

Zweifel, P., S. Felder, M. Meiers (1999), "Ageing of the Population and Health Care Expenditure: A Red Herring?", *Health Economics* 8, 485-496.

ANNEX I: SPECIFICATION OF THE UTILITY FUNCTION AND THE INCOME ELASTICITY

153. In this Annex we show the relation between the specification of the utility function used in Hall and Jones (2007) and the value of the income elasticity. Assume that a social planner chooses consumption and health spending to maximize the utility of the individual, *e.g.* the optimal allocation solves the following program,

$$max_{c,h} f(h)u(c) \text{ s.t. } c + h = y$$

where

$$u(c) = b + \frac{c^{1-\gamma}}{1-\gamma}$$
$$f(h) = A_a h^{\theta_a}.$$

154. This programme is similar to the Hall and Jones' model (see Box 3 in the text). Under standard regularity conditions, the first-order conditions are given by:

$$f(h)u'(c) - \lambda = 0 \quad (1)$$
$$f'(h)u(c) - \lambda = 0 \quad (2)$$
$$c + h = y. \quad (3)$$

Using (1) and (2), we have:

$$\frac{f(h)}{f'(h)} = \frac{u(c)}{u'(c)}$$

or

$$\frac{h}{c} = \frac{\eta_h}{\eta_c}$$

where $\eta_h = h\frac{f'(h)}{f(h)}$ and $\eta_c = c\frac{u'(c)}{u(c)}$.

155. Solving the first-order conditions we one obtain:

$$h = \theta_a \left(\frac{b + \frac{c^{1-\gamma}}{1-\gamma}}{c^{-\gamma}} \right)$$

which implies from equation (3) :

$$c + \theta_a \left(\frac{b + \frac{c^{1-\gamma}}{1-\gamma}}{c^{-\gamma}} \right) = y.$$

It is straightforward to see that:

$$\frac{dc}{dy} = \frac{1}{(1-\gamma)\left(1+\frac{\theta_a}{1-\gamma}\right)+\gamma\frac{y}{c}}$$

$$\eta^*_{y/c} = \frac{1}{(1-\gamma)\left(1+\frac{\theta_a}{1-\gamma}\right)(1-s^*)+\gamma}$$

156. Where $s^*=h/y$ is the optimal share of health spending in GDP. Some algebraic manipulations yield the income elasticity of the health demand:

$$\eta^*_{y/h} = \frac{\theta_a\left(b\gamma\left(c^*\right)^{1-\gamma}+\frac{1}{1-\gamma}\right)\left(\frac{1-s^*}{s^*}\right)}{(1-\gamma)\left(1+\frac{\theta_a}{1-\gamma}\right)\left(1-s^*\right)+\gamma}.$$

157. The income elasticity depends on b, γ, and θ_a (since s^* depends on η_h and η_c, which in turn depends on the parameters of u and f). In particular, it could be larger or lesser than one, depending on the values of the parameters and the optimal consumption allocation. However, in the particular case where $b=0$, we have $s^* = h/y = 1/(1+\eta_c/\eta_h) = 1/(1+(1-\gamma)/\theta_a)$ and the income elasticity is equal to one. In other words, the fact that the optimal share of health spending is rising with GDP depends critically on a strictly positive b parameter. Hall and Jones acknowledge the critical importance of this condition for their results, without establishing the formal relationship between the form of the utility function and the income elasticity.

ANNEX II: DATA SOURCES AND METHODS OF HEALTH EXPENDITURE PROJECTIONS[39]

Estimating death-related costs

158. The primary data for 18 OECD countries are drawn from the AGIR data set (Westerhout and Pellikaan, 2005, based on EC-EPC, 2001) for EU-15 countries and from national sources for Australia, Canada and United States.

159. The cost of death for the oldest group (95+) is assumed to be the lowest and was proxied by their observed health expenditure per person when available. For France, Germany, Italy, United Kingdom, Spain, Netherlands and Australia for which the expenditure for the oldest group were not available, the cost of people aged 75-79 was taken as a proxy. In fact, when available, expenditure at age 95+ is roughly equal to the level of expenditure at age 75-79. For the countries where no cost expenditures were available, the cost of death for the oldest group was estimated by taking 3 times the average health expenditure per capita.

160. The costs of death for other age groups are then derived by multiplying this estimate by an adjustment factor equal to four between ages 0-4 to 55-59, gradually decreasing to 1 afterwards. Multiplying these costs of death by the estimated number of deaths by age group (using mortality data) gives the death-related cost (DRC) curve.

Calibration of the expenditure curves on the OECD Health database

161. The cost curves derived for the year 2000 were first calibrated in order to fit with levels of 2005, the starting point of the projections. The total health and long-term care expenditures for 2005 being not yet available in the OECD Health Data (2005a), an estimate was made by applying the observed growth rate in expenditures 2000-2003 (or 2002, depending on the countries) for the whole period 2000-2005. A second step was to split the total spending into health and long-term care. The details of this split are provided below and involved an estimate of the shares of long-term care expenditures using OECD (2005b).

162. The costs of death by age group for 2005 were derived by applying the same growth rate as the total health expenditures between 2000 and 2005. The total death-related costs in 2005 were computed as the product of the cost of death by the projected number of deaths by age group in that year. The total survivor expenditures were then derived by subtracting the total death-related costs from the total health spending. Using this information, the survivor cost curve was calibrated proportionally for each age group.

---

[39] This Annex draws from Oliveira Martins and de la Maisonneuve (2006).

Projecting the demographic effects under a "healthy ageing" scenario

163. Shifting the survivor cost curve according to longevity gains involves two steps:

(1) The survivor expenditure curve by five-year age groups is interpolated in order to derive a profile by individual age. In this way, the cost curve can be shifted smoothly over time in line with life expectancy gains.

(2) An "effective age" is calculated by subtracting the increase in life expectancy at birth according to national projections from current age. For example, a 70-year old person in Germany is projected to have an effective age of 67 by 2025 and 64 by 2050.

The starting point of the projections

164. The projected changes in spending expressed in percentage of GDP were calculated from a common base applied to all OECD countries. This base was taken as the OECD average of expenditure in 2005. These changes were added to the initial level of expenditures in each country. This approach makes the projected changes (expressed in percent of GDP) less dependent from the base year levels and also allows for a certain catch-up of expenditure ratios across countries. More precisely, the variation of the share of expenditure to GDP in country *j* between, say, 2005 and 2050, is calculated as:

$$\Delta\left(\left.\frac{Expenditure}{GDP}\right|_{\substack{country\ j\\2050-2005}}\right)=\exp\left[\left.\Delta\log(Drivers)\right|_{\substack{country\ j\\2050-2005}}+\log\left(\left.\frac{Expenditure}{GDP}\right|_{\substack{average\,OECD\\year=2005}}\right)\right]-\left(\left.\frac{Expenditure}{GDP}\right|_{\substack{OECD\ \ average\\year=2005}}\right)$$

TABLES & FIGURES

Diagram 1. Links between Health spending, Technological progress, Longevity and the GDP

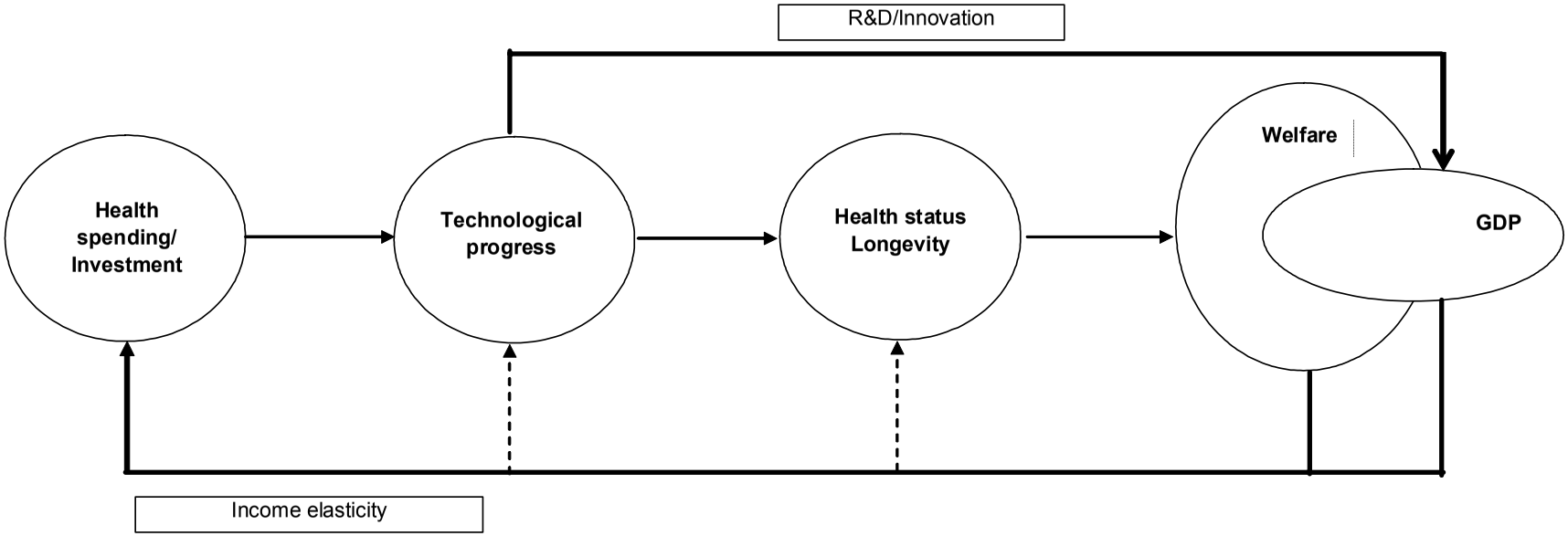
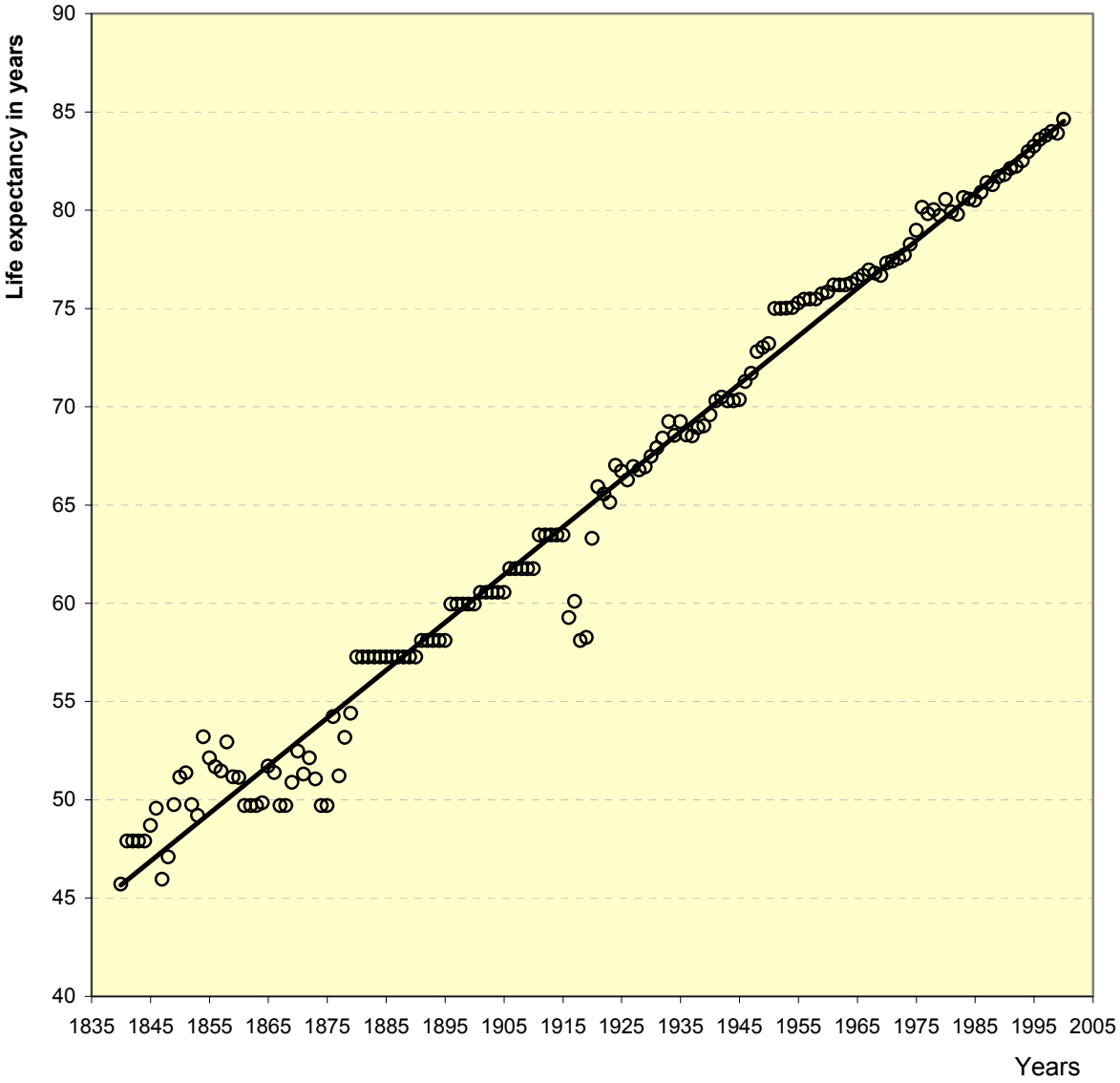
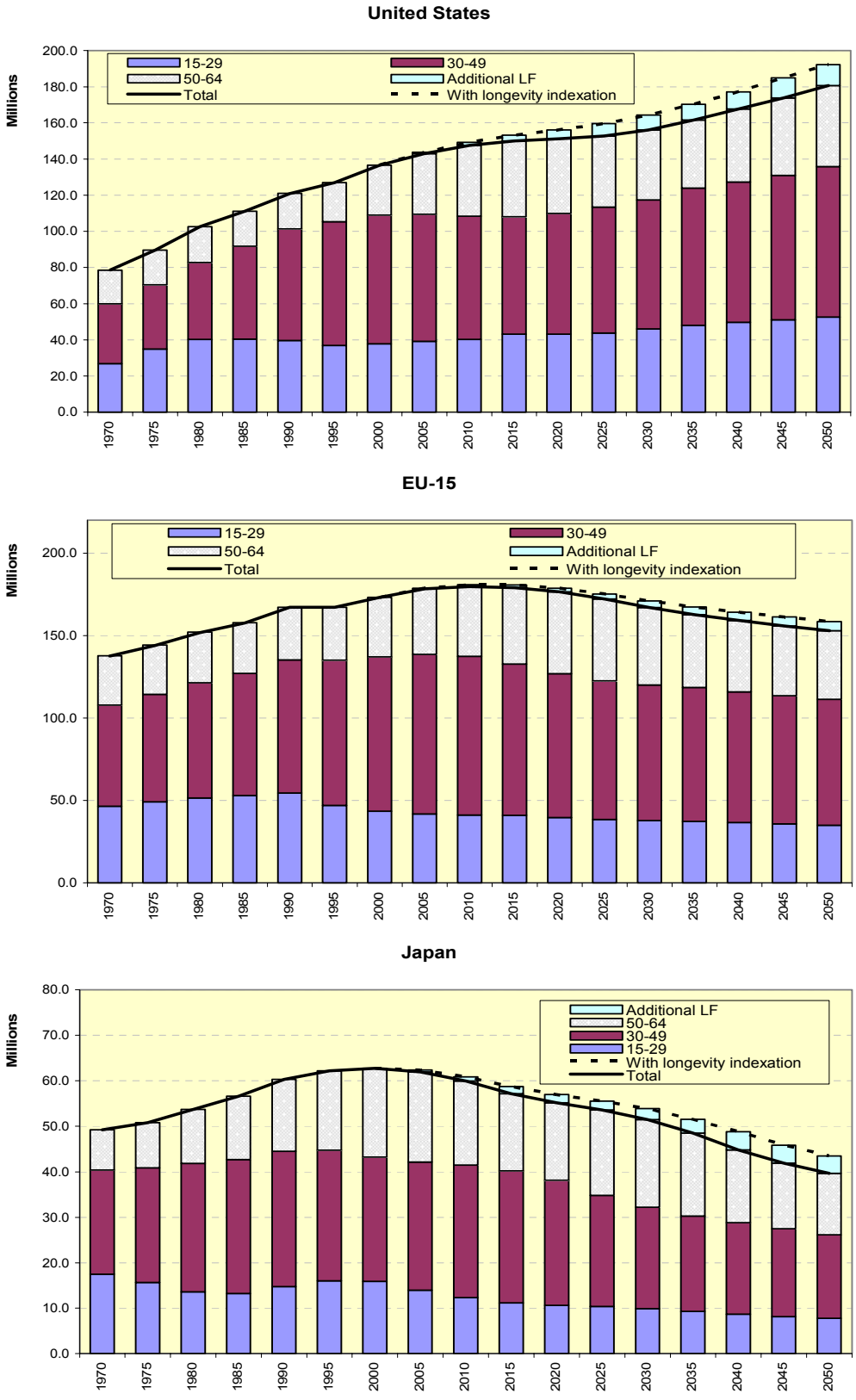


Figure 1.1 Historical trends in female life expectancy, 1840-2000 [1]



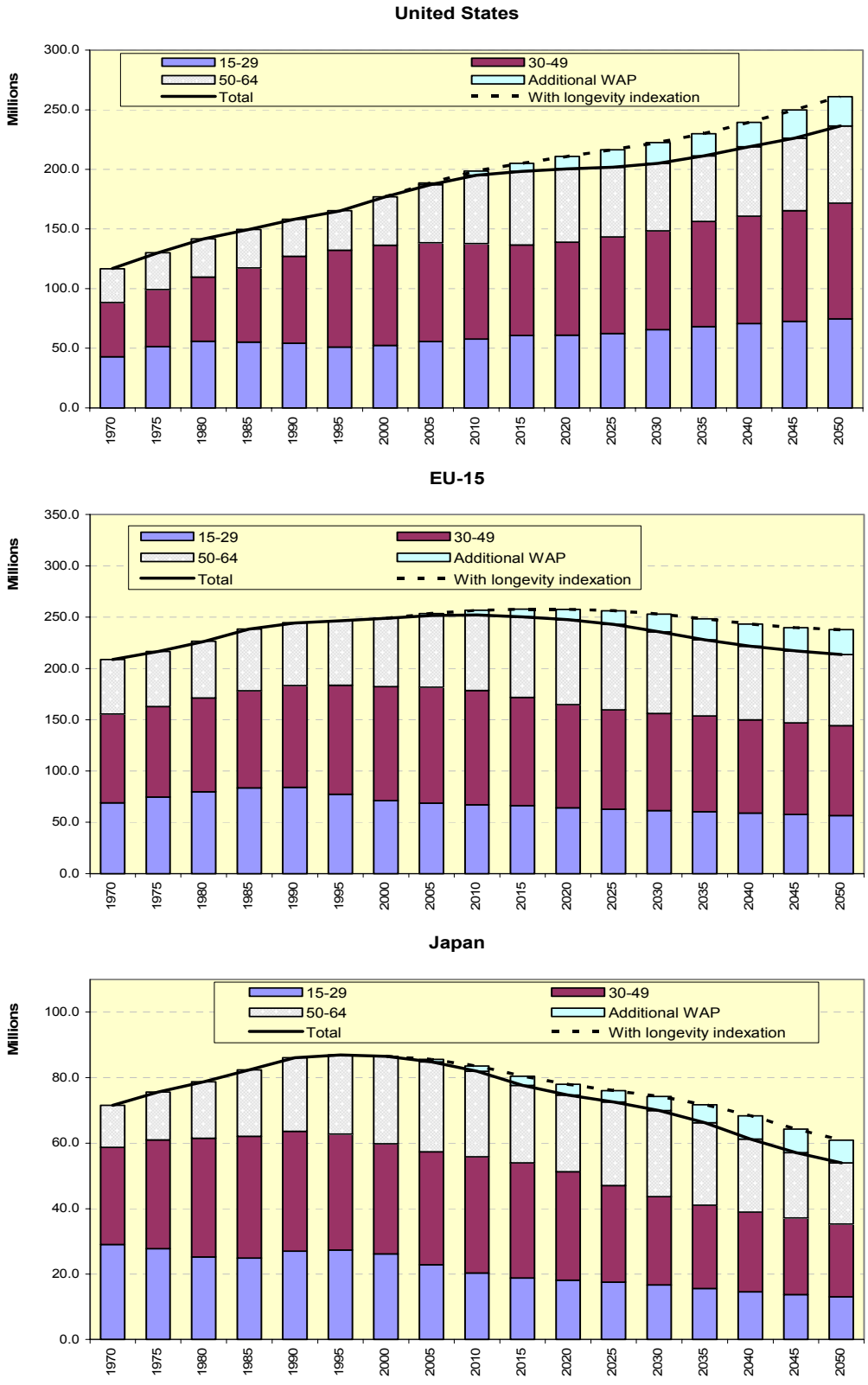
1. Country with the highest life expectancy. The linear trend: slope=2.43 and R^2=0.98.
Source: Oeppen and Vaupel (2002).

Figure1.2 Simulations of the effect of ageing and longevity on the labour force[1]



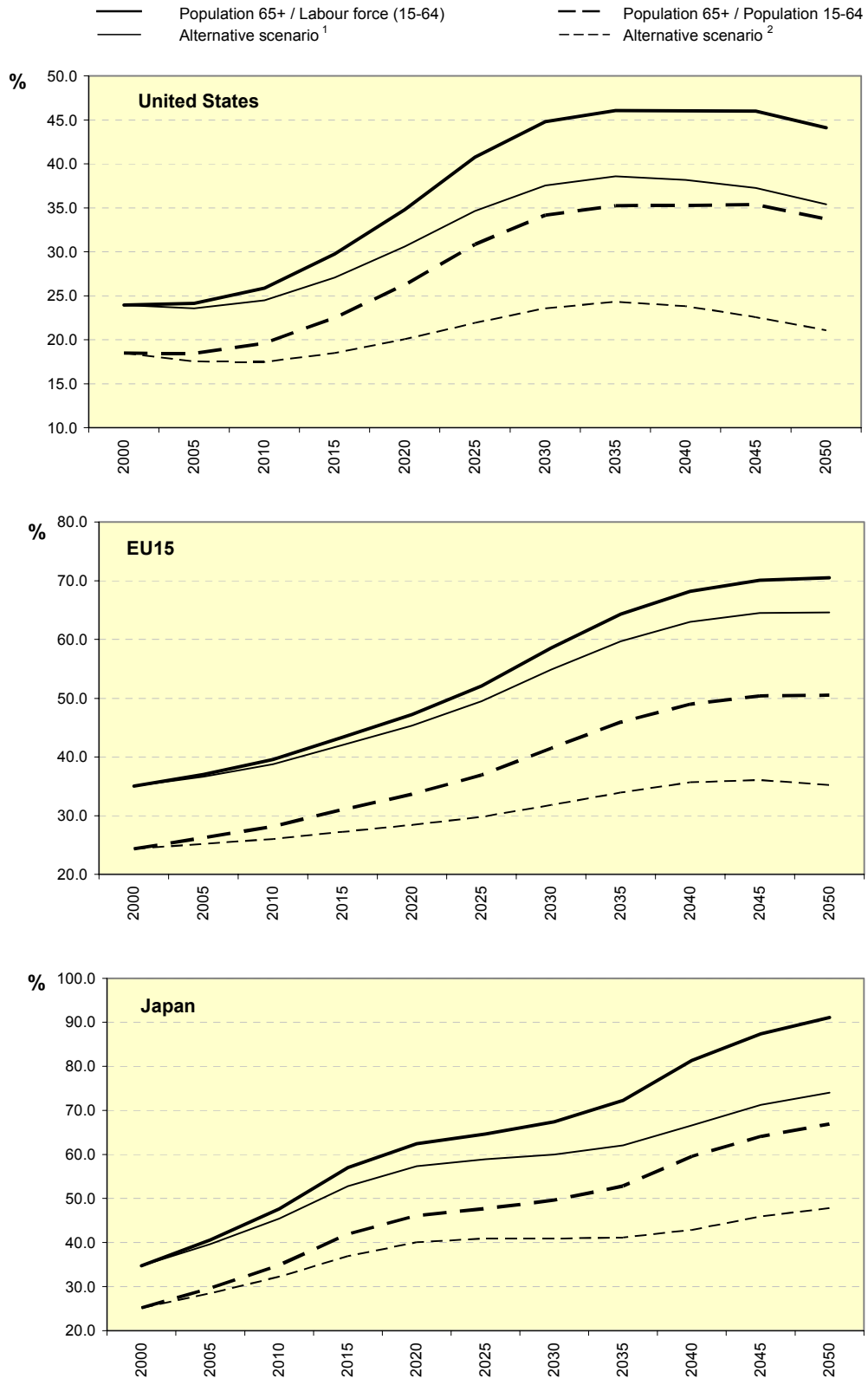
(1) The labour force projections are derived from te baseline scenario of Burniaux et al. (2003). The longevity indexation method is described in Oliveira Martins et al. (2005).

Figure 1.3 Simulations of the effect of ageing and longevity on the working-age population



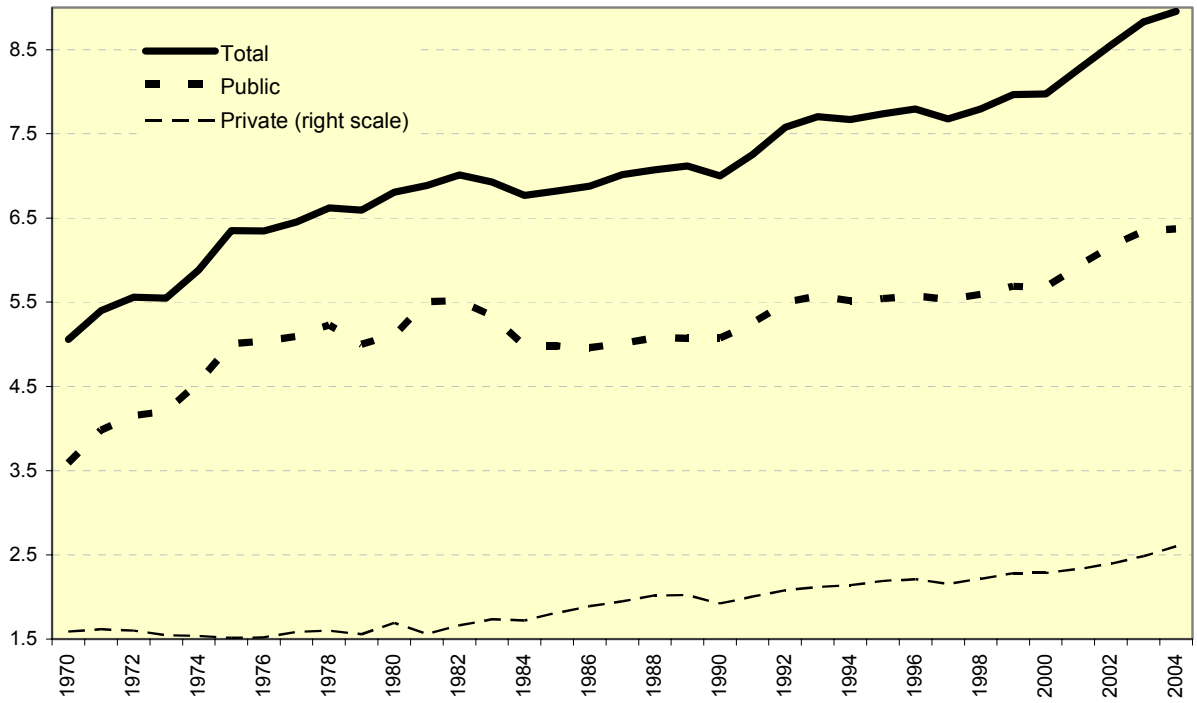
(1) The labour force projections are derived from te baseline scenario of Burniaux et al. (2003). The longevity indexation method is described in Oliveira Martins et al. (2005).

Figure 1.4 Simulations of longevity indexation on dependency ratios



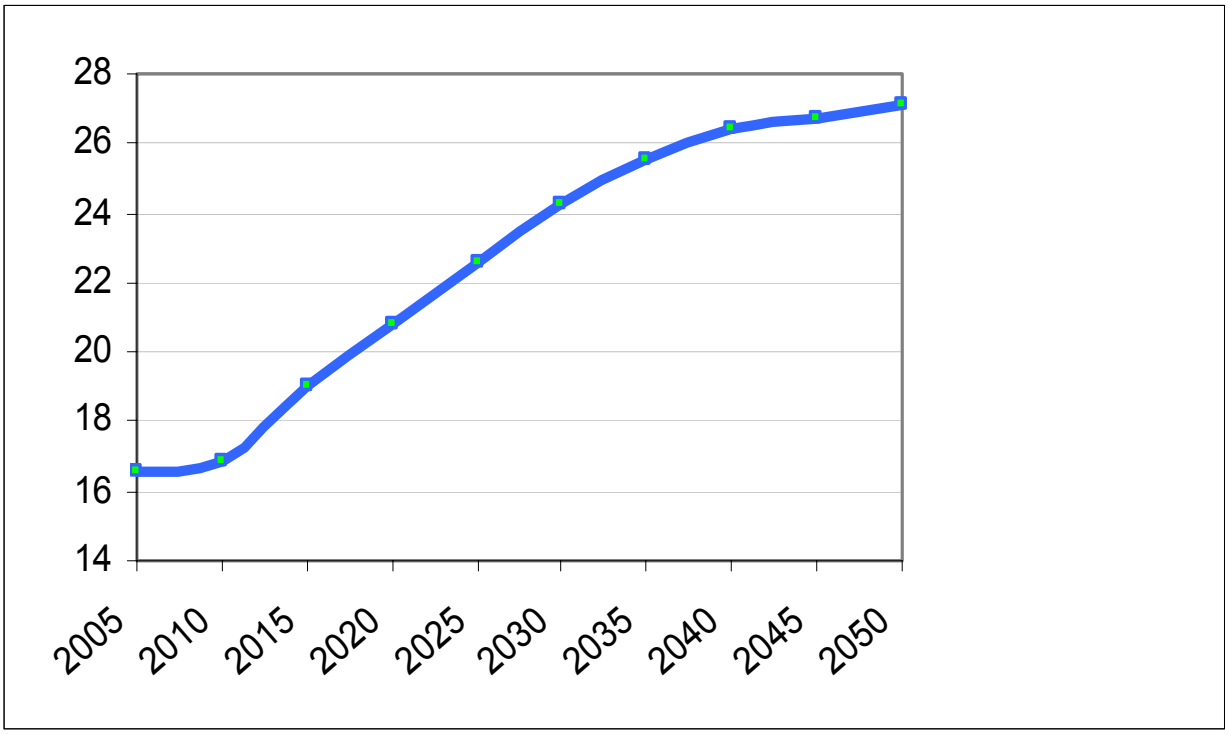
1. Population in retirement / Labour force, indexed on longevity.
2. Population in retirement / Working age population, indexed on longevity.

Figure 2.0 Evolution of Total, Public and Private OECD health spending (in % of GDP)



1. Unweighted average of available OECD countries. Including long-term care expenditure.
Source : OECD Health Database (2006).

Figure 2.1 Proportion of people aged 65 and over (demographic effect), France

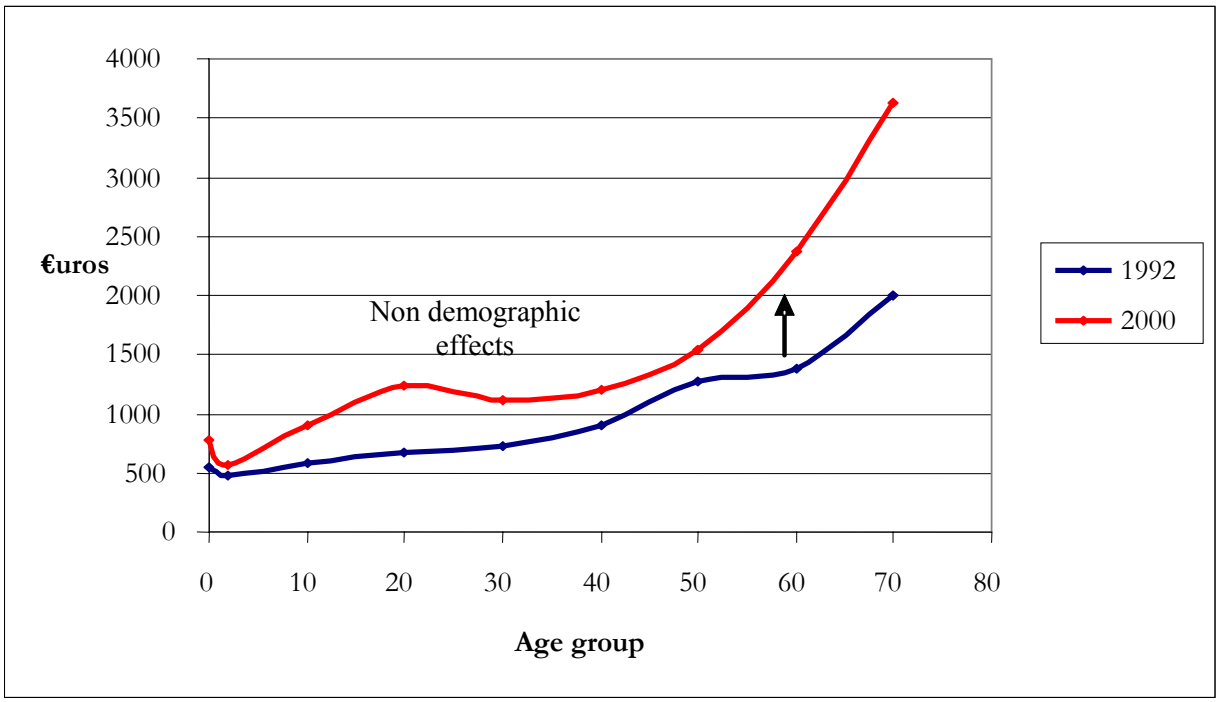


Source: OECD

Figure 2.2 Individual health expenditure by age group (Euros), France

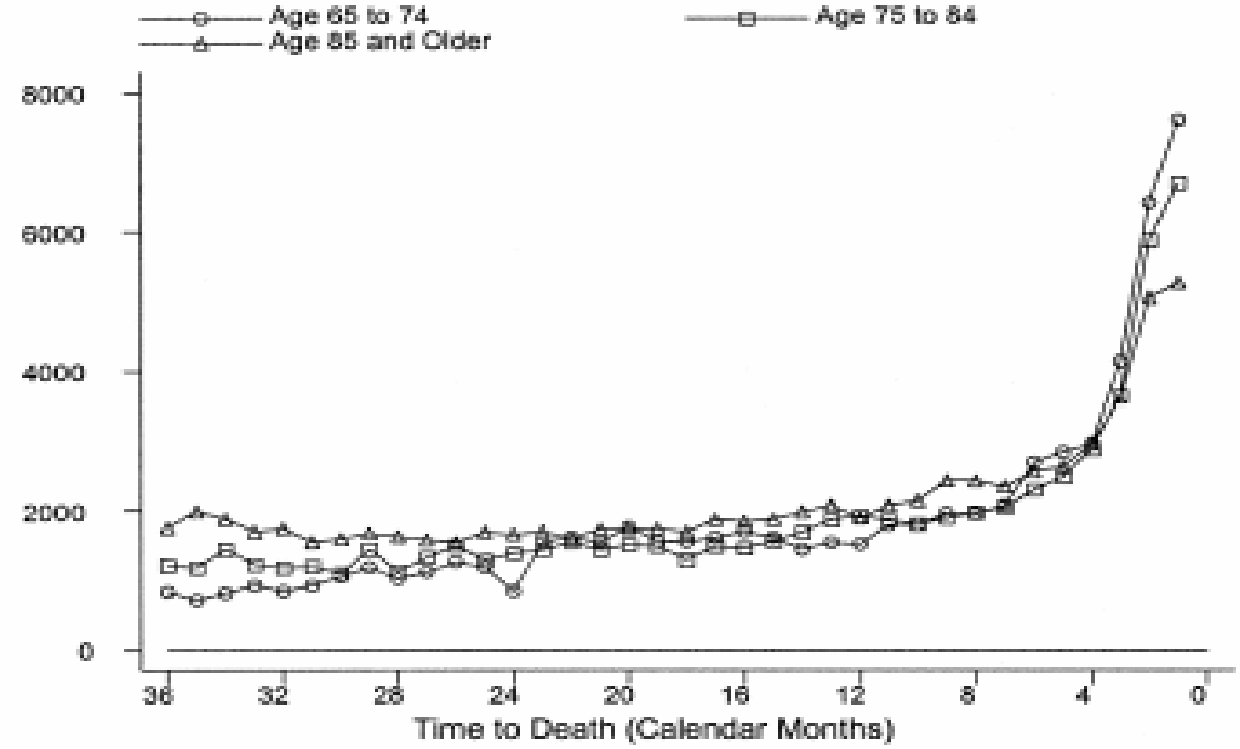
Source: Dormont, Grignon & Huber (2006)

Figure 2.3 Health expenditures by age group (euros), 1992 & 2000, France



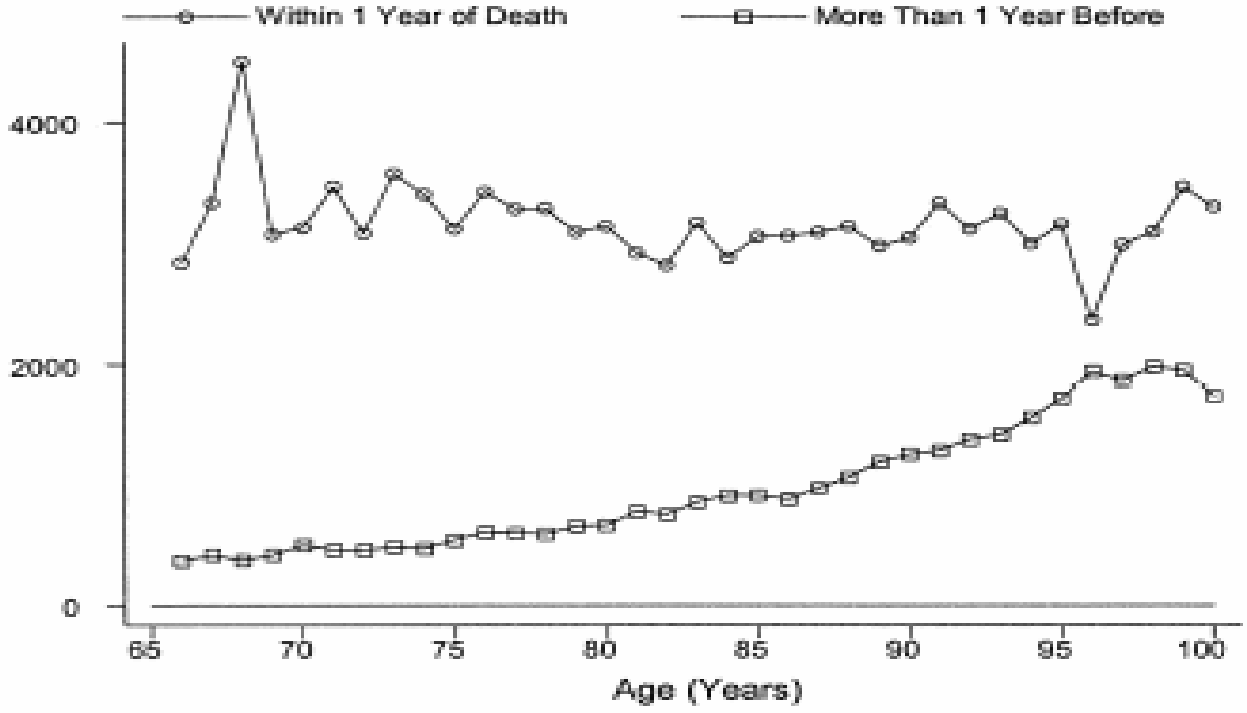
Source: Dormont, Grignon & Huber (2006)

Figure 2.4: Individual health expenditure ($) in relation to death proximity
Medicare beneficiaries (USA)



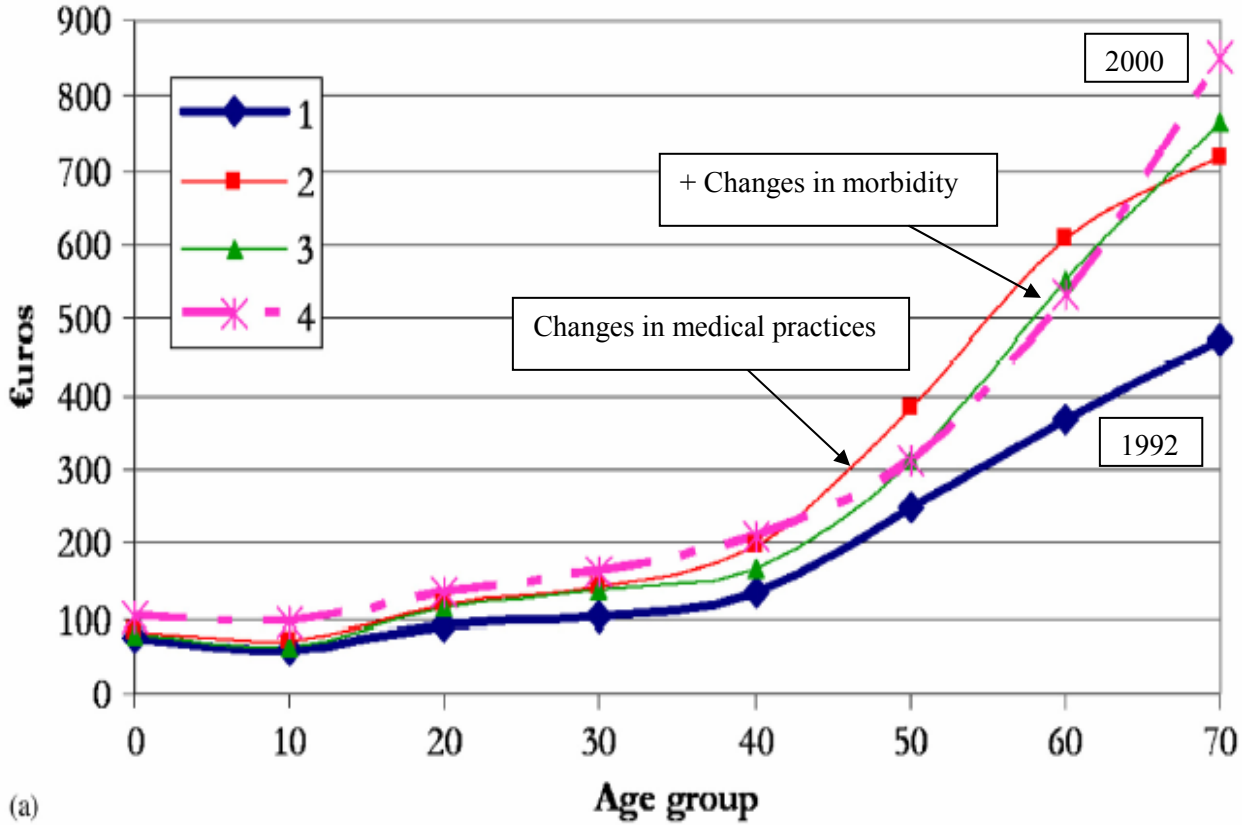
Source: Yang *et al.* (2003)

Figure 2.5: Individual health expenditure ($) by age group decedents versus survivors
Medicare beneficiaries (USA)



Source: Yang *et al.* (2003)

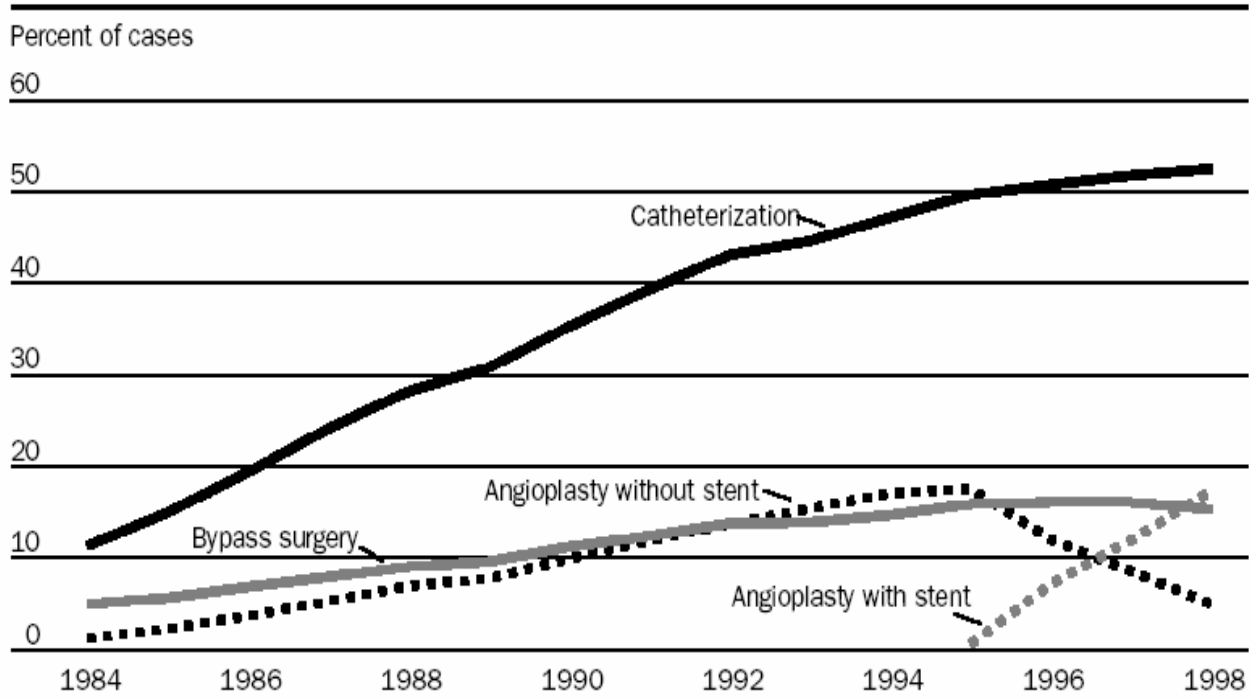
Figure 2.6: Decomposition of the drift of the age profile of individual Pharmaceutical expenditures, France (micro-simulations), 1992-2000



(a)

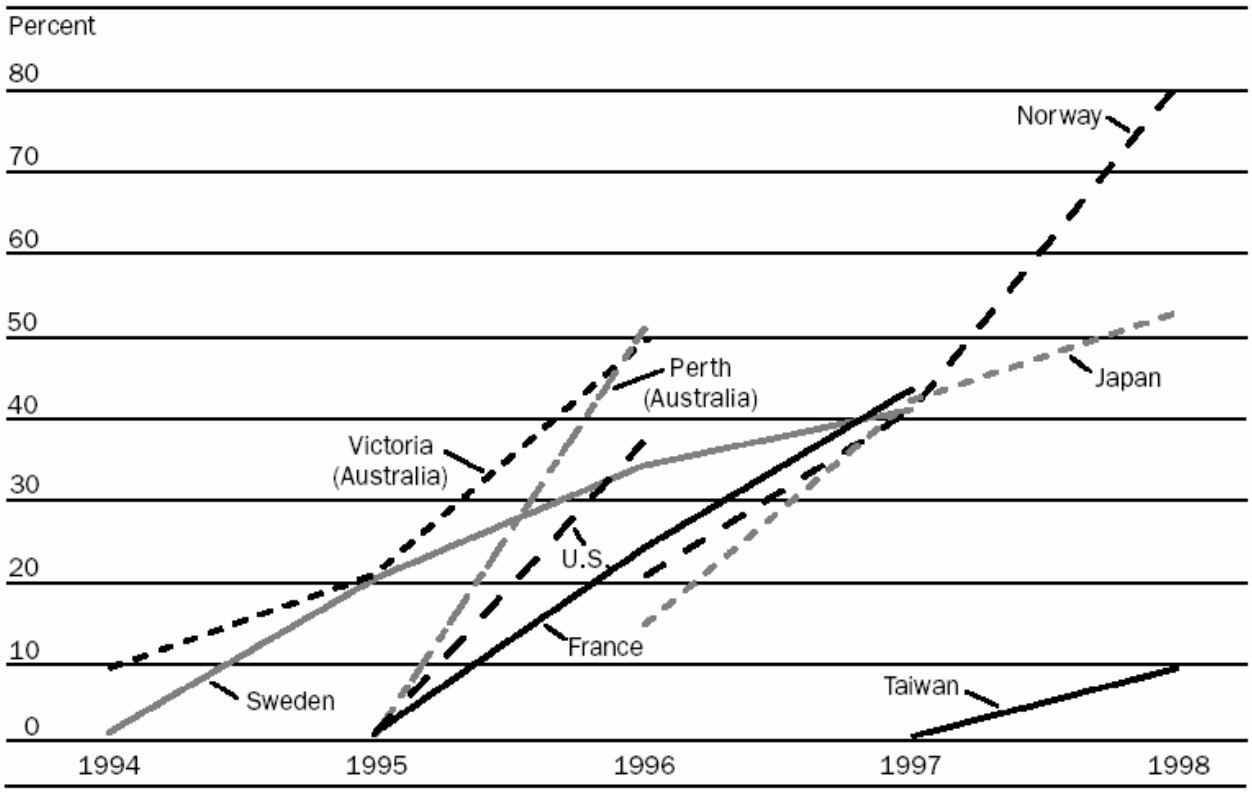
Source: Dormont, Grignon & Huber (2006)

Figure 2.7: Changes in the surgical treatment of heart attack USA, 1984-1998



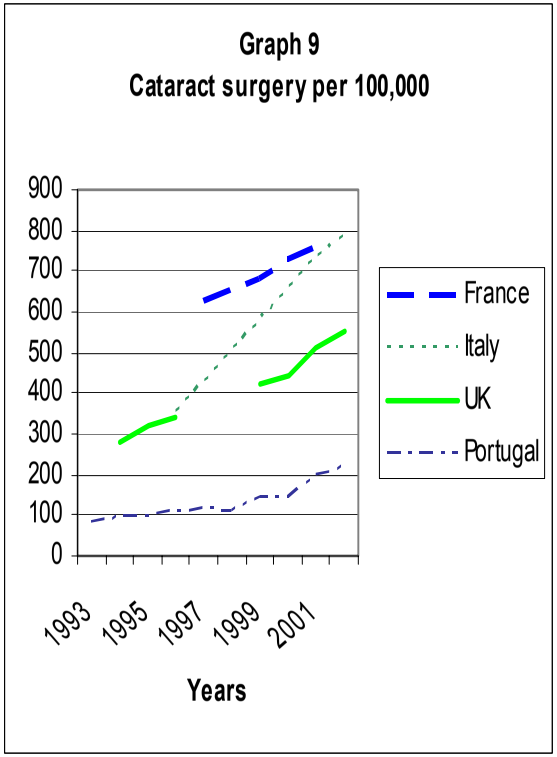
Source: Cutler & McClellan (2001)

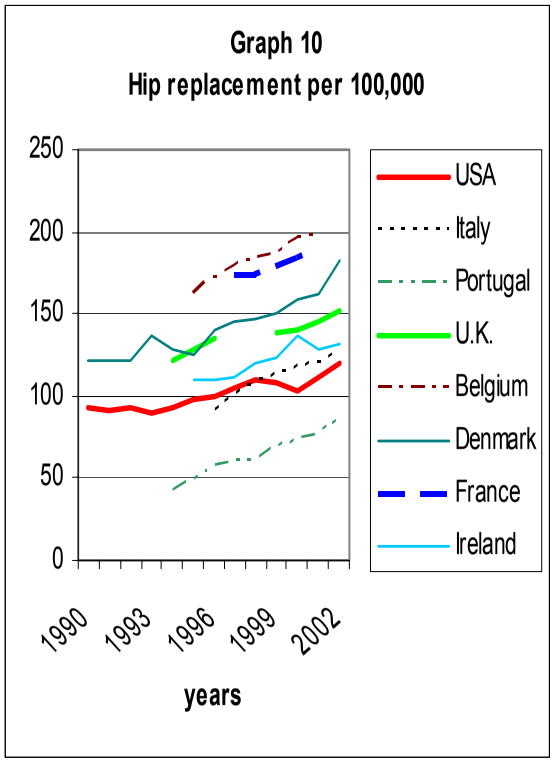
Figure 2.8: Share of angioplasty procedures involving stents in heart attack admissions Selected countries 1994-1998

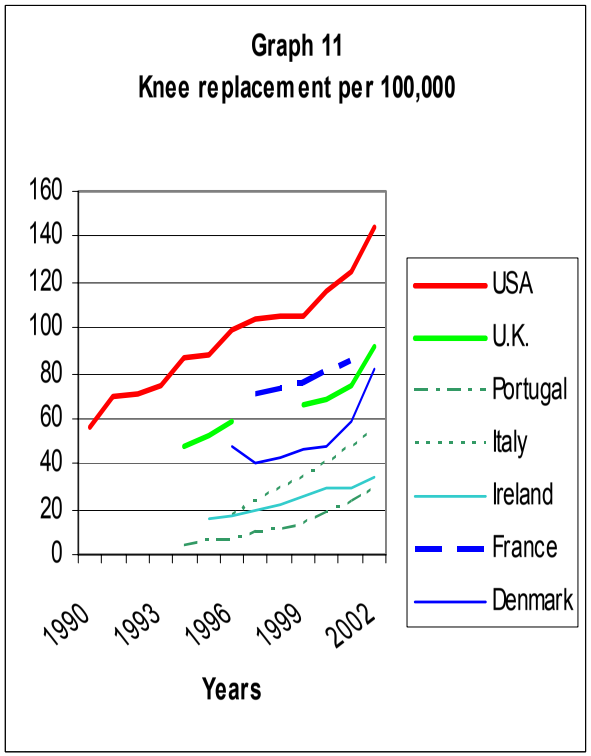


Source: TECH Research Network (2001)

Figures 2.9-2.11: Use of cataract surgery, hip and knee replacement in OECD countries

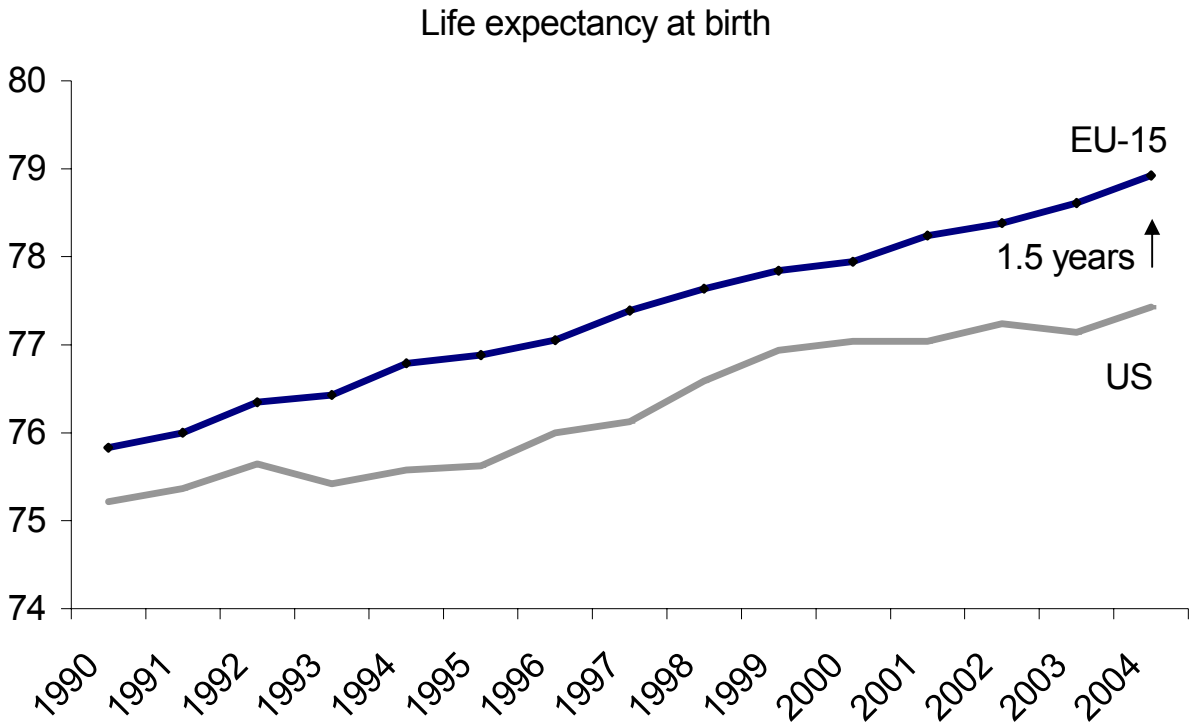






Source: OECD Health Data (2004)

Figure 2.12: Life expectancy at birth in the EU-15 and the US, 1990-2004



Source: World Bank (2006)

Diagram 2.1: Three possible scenarios for future changes in morbidity at a given age

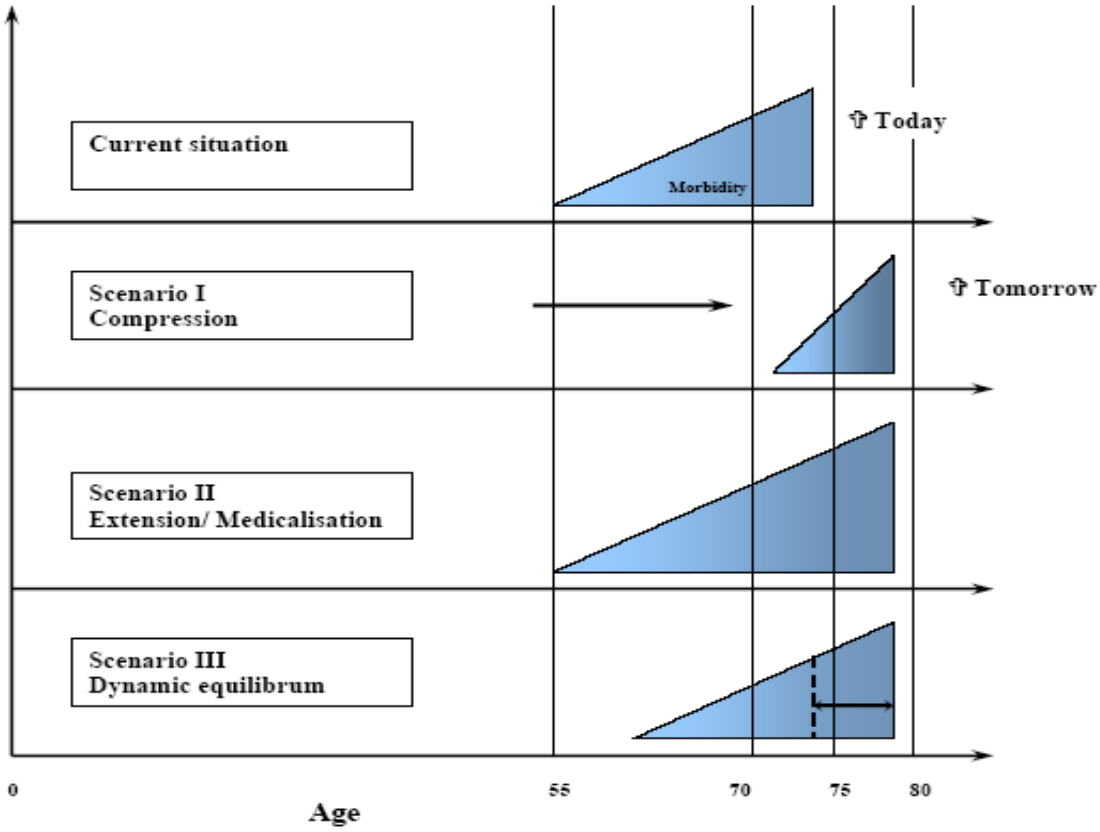
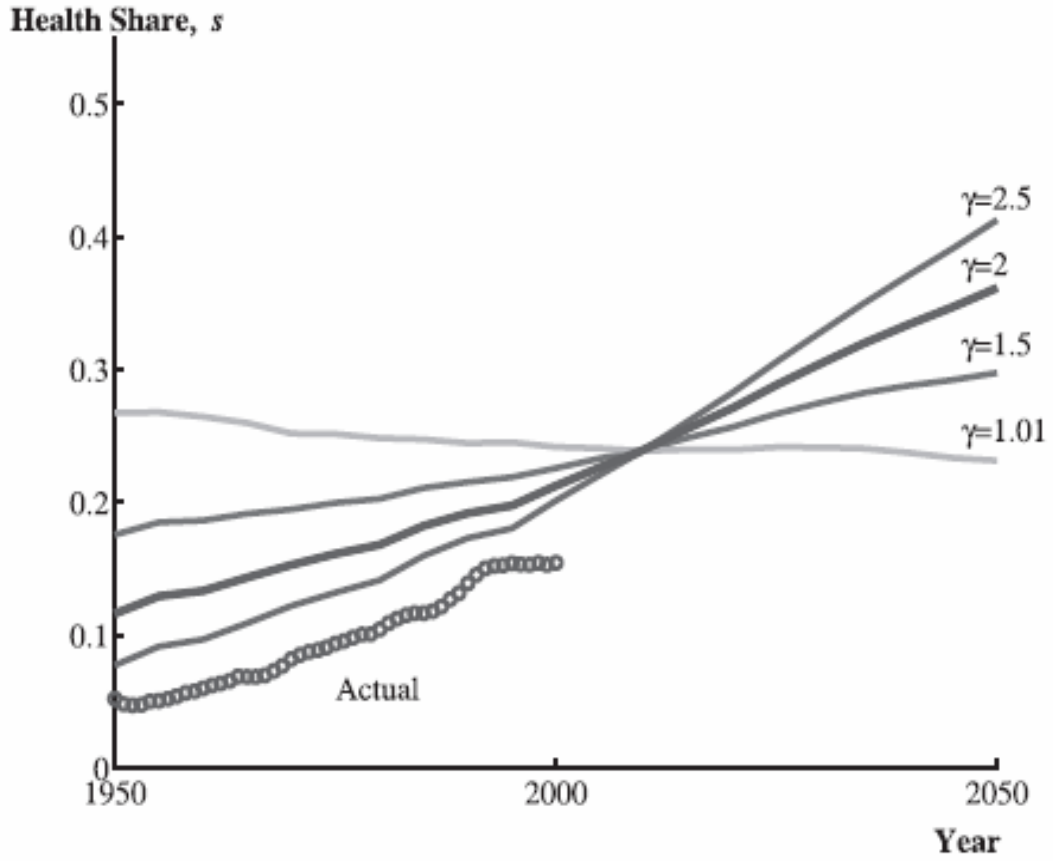
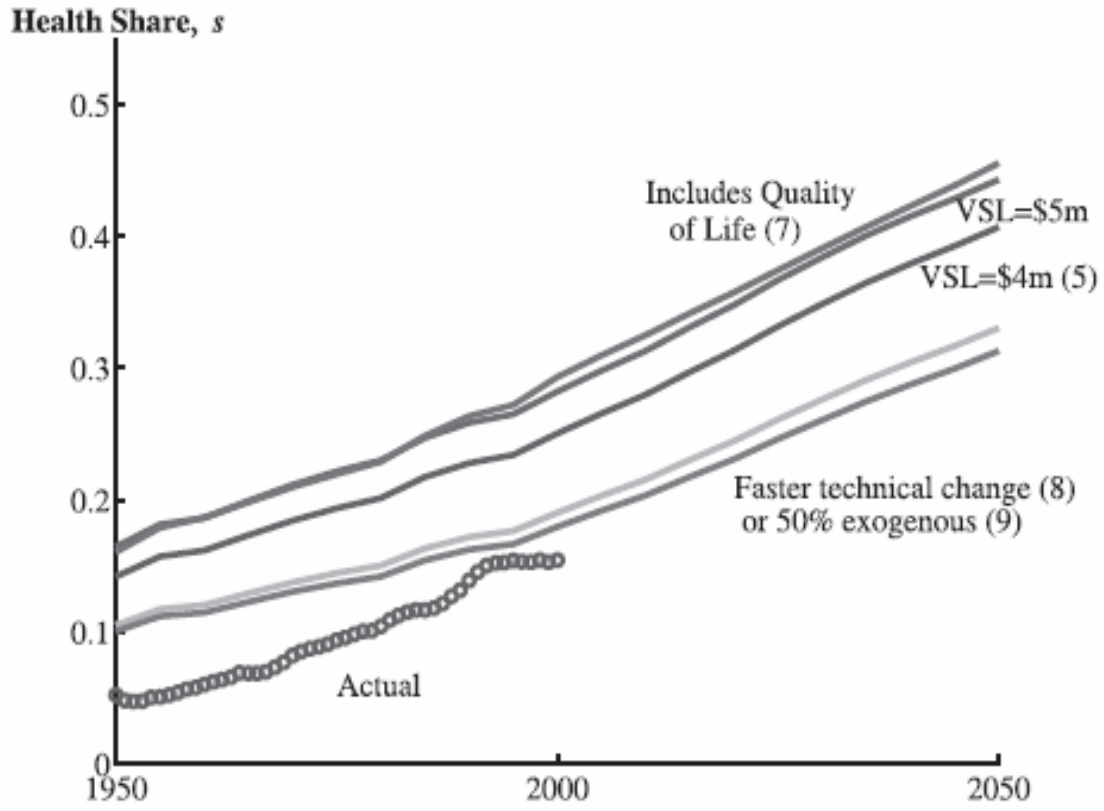


Figure 2.13: The increase in the optimal share of spending devoted to health care



Source: Hall and Jones (2007)

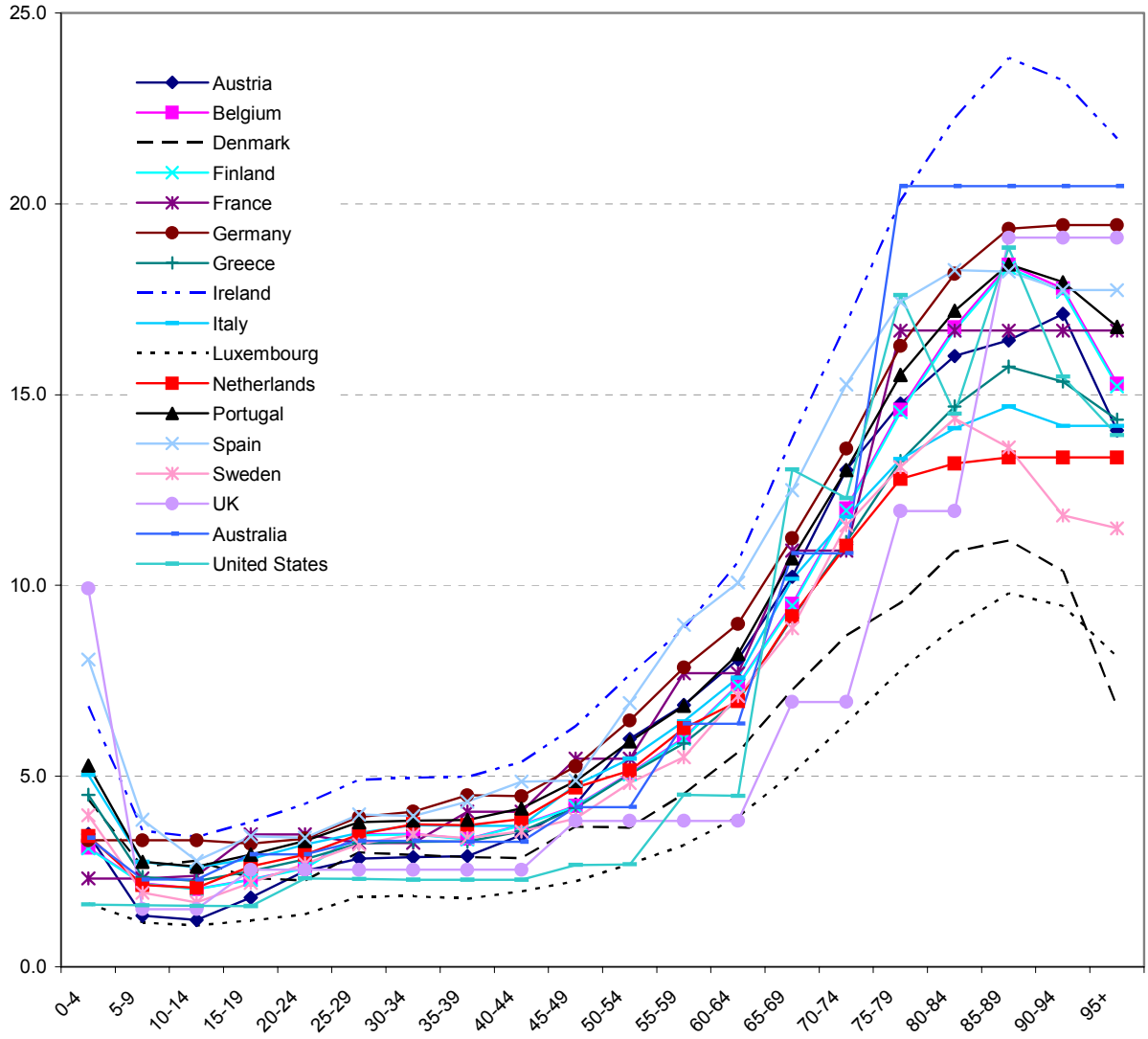
Figure 2.14: The optimal share of spending devoted to health care



Source: Hall and Jones (2007)

Figure 4.1 Public Health care expenditures by age Groups[1], 1999

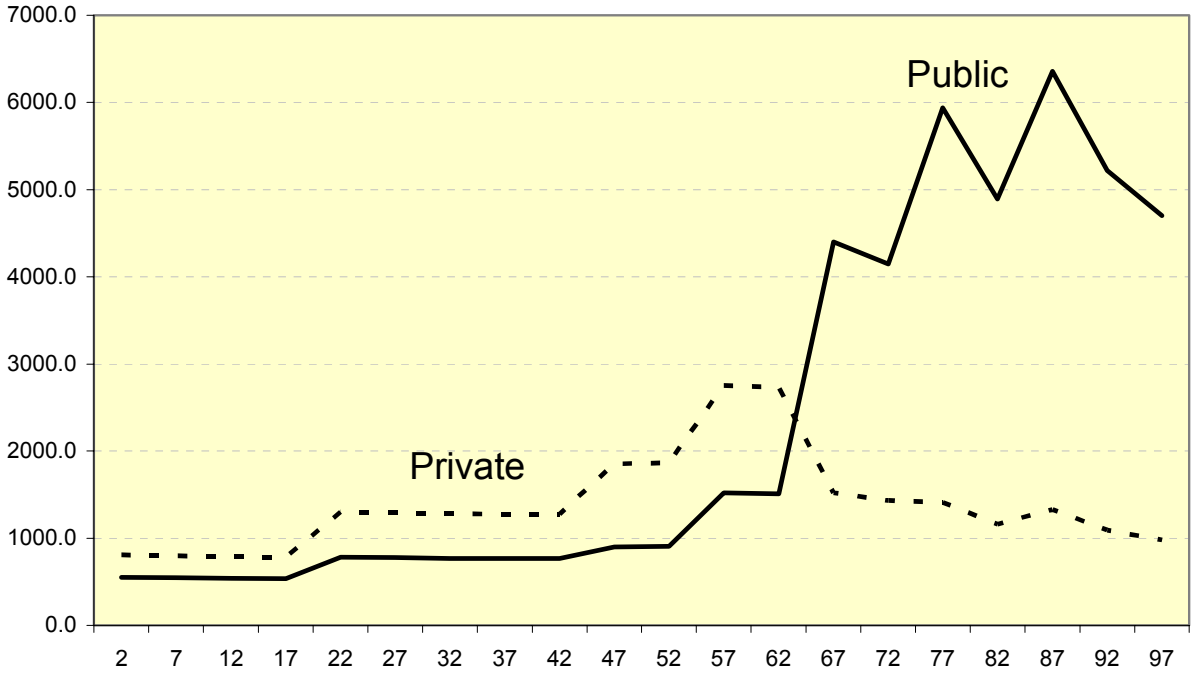
(in % of GDP per capita)



1. Expenditure per capita in each age group divided by GDP per capita, 1999.
Source : ENPRI-AGIR, national authorities and authors' calculations.

Figure 4.2 Public and private health expenditure per capita[1]

In US$ PPPs



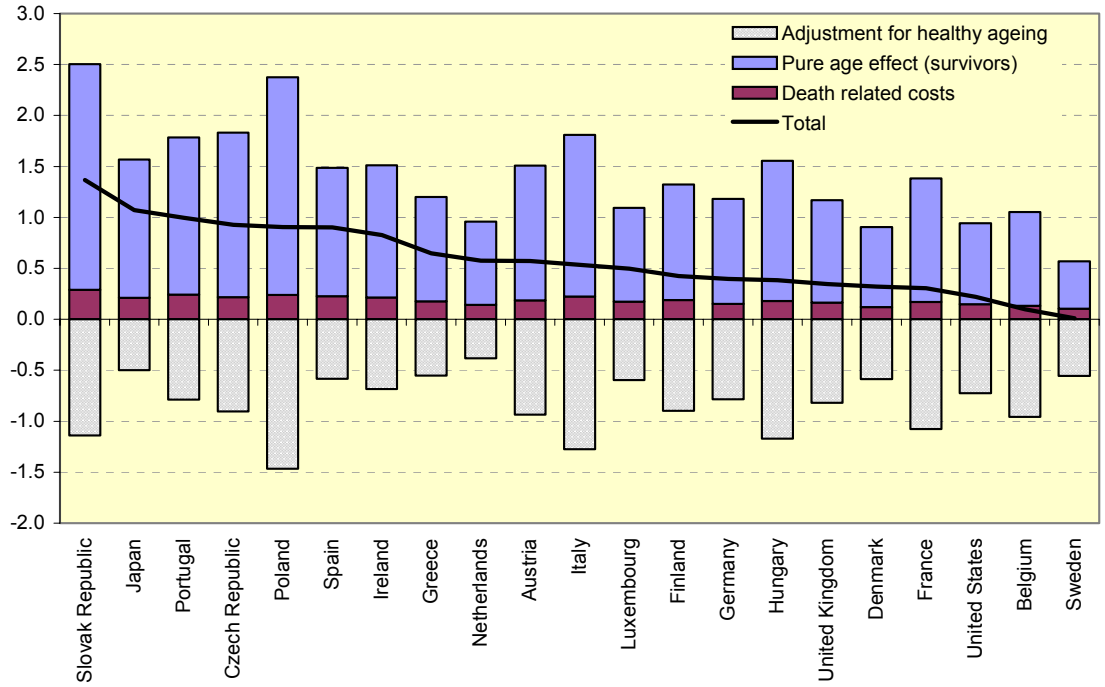
(1) Excluding long-term care

Source: US Centers for Medicare and Medicaid Services, Office of Actuary, National Health Statistics Group

Figure 4.3 Demographic effects on health care expenditure

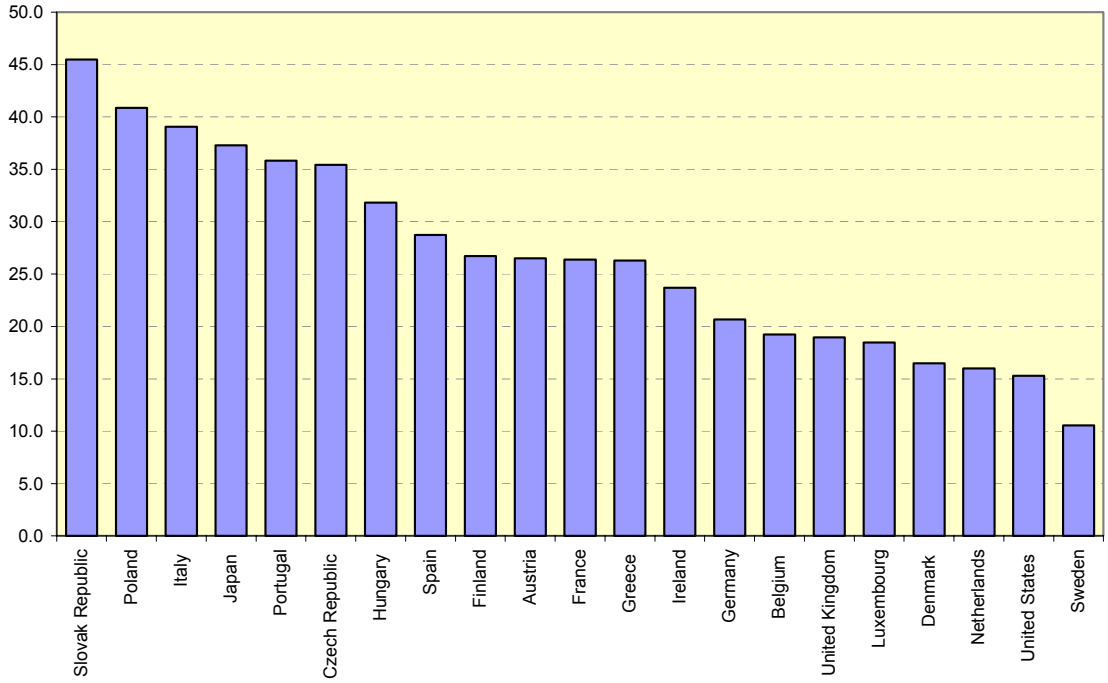
A. **Public health care expenditure**

Increase in % points of GDP 2005-2050



B. **Increase in the old-age dependency ratio between 2005 and 2050** [1]

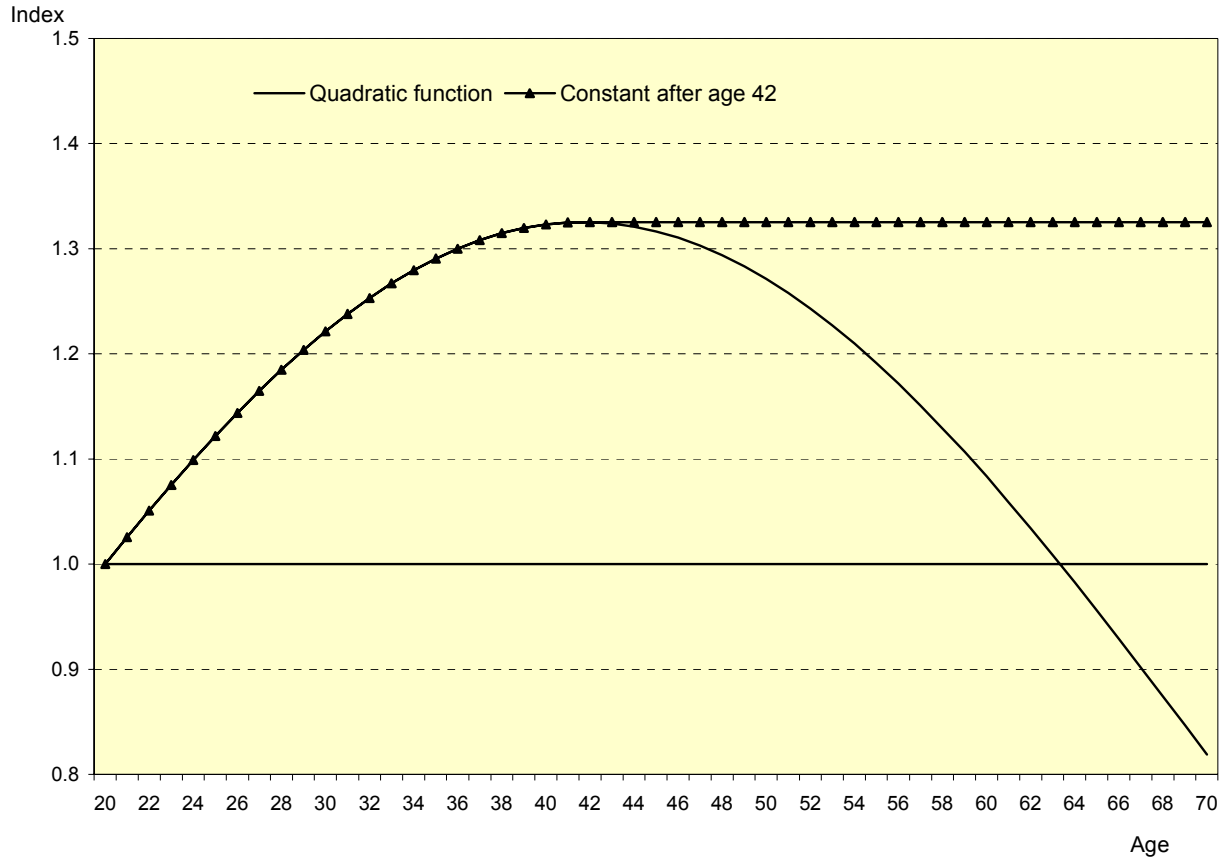
(In percentage points of working age population)



1. Ratio of population aged 65 and over to population aged 15-64.

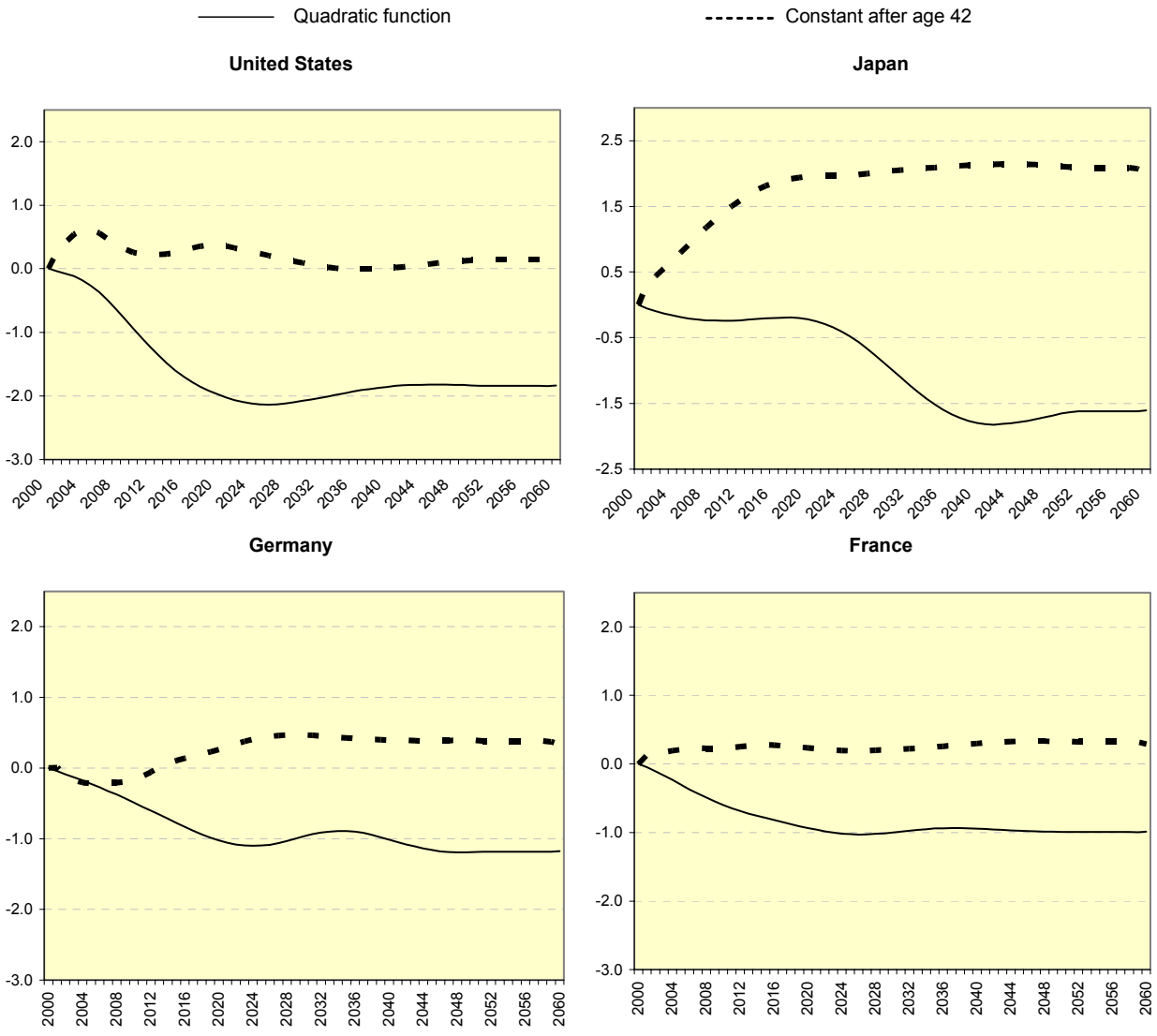
Source : Oliveira Martins and de la Maisonneuve (2006).

Figure 5.1 Different age-productivity profiles



Source : Oliveira Martins et al. (2005)

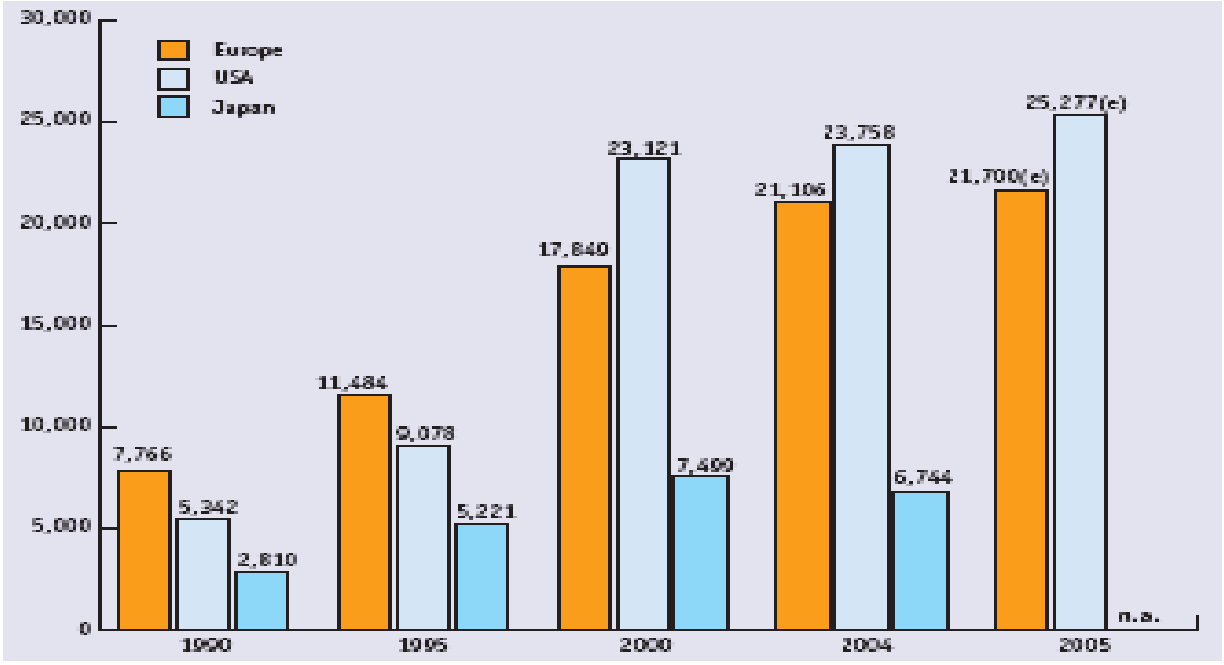
Figure 5.2 Mechanical impact of ageing on productivity levels
(Per cent changes relative to 2000 levels)



Note: Impact of multiplying the projected change in the structure of the labour force by productivity-age profiles of Figure 5.1.
Source: Oliveira Martins et al. (2005)

Figure 5.3 Pharmaceutical R&D expenditure in Europe, the US and Japan

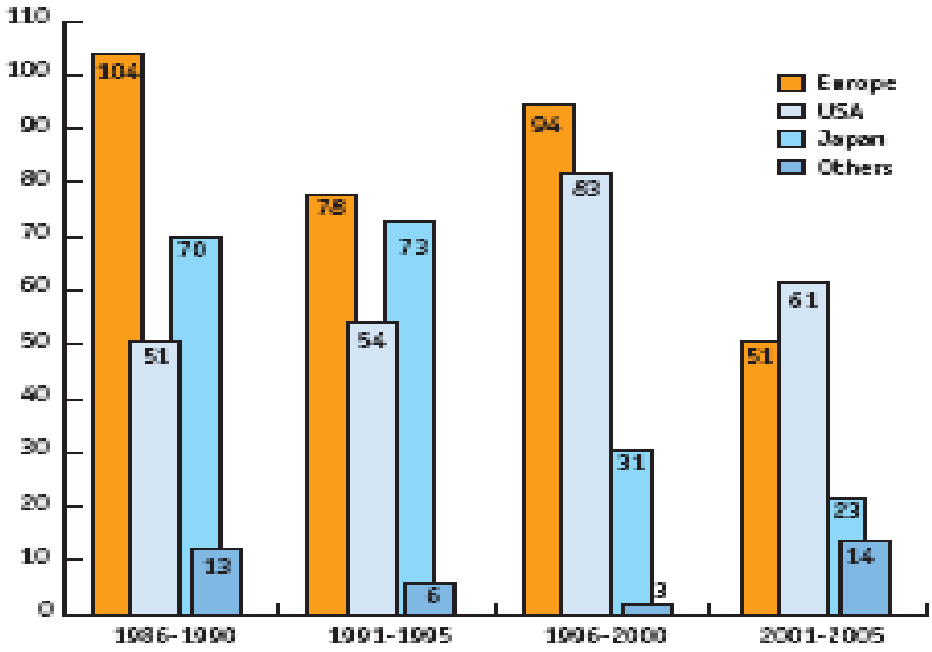
(million €, current exchange rates)



Source: EFPIA (2006)

Note: (e) stands for estimates.

Figure 5.4 New chemical or biological entities



Source: EFPIA (2006)

Table 1.1 Increases in life expectancy for different age groups

Change in years over the last 40 years [1]

	Females					Males				
	at birth	at age 40	at age 60	at age 65	at age 80	at birth	at age 40	at age 60	at age 65	at age 80
United States	6.4	4.5	3.6	3.4	2.3	7.5	5.5	4.1	3.5	1.6
Europe										
Austria	9.3	6.1	5.3	4.9	2.5	10.0	6.1	5.0	4.2	2.2
Belgium	7.3	5.7	5.1	4.7	2.3	6.9	4.9	3.8	3.1	1.4
Czech Republic	5.0	3.4	2.8	2.6	1.4	3.8	1.4	1.4	1.2	0.5
Denmark	4.9	3.3	3.0	3.0	n.a	4.1	2.2	1.8	1.5	n.a
Finland	8.5	7.0	6.1	5.6	2.6	8.7	6.4	4.8	4.0	1.6
France	9.1	6.4	5.8	5.3	3.0	8.2	5.3	4.6	4.0	2.3
Germany	8.3	5.7	4.9	4.6	2.4	7.8	4.5	3.7	3.1	1.6
Greece	8.2	5.7	4.6	4.1	1.2	8.2	3.5	3.2	2.9	1.4
Hungary	5.6	2.3	2.6	2.5	1.5	1.3	-2.6	-0.3	0.3	0.9
Ireland	7.3	5.0	3.8	3.3	n.a	6.1	3.7	2.5	2.0	n.a
Italy	10.1	n.a	n.a	n.a	n.a	9.1	n.a	n.a	n.a	n.a
Luxembourg	9.1	6.6	5.8	5.3	3.4	8.4	5.0	3.8	3.1	1.5
Netherlands	5.1	4.4	4.1	3.9	2.1	4.0	2.7	1.8	1.4	0.7
Poland	7.3	3.0	2.7	2.4	1.2	4.8	0.1	0.8	0.9	0.9
Portugal	12.9	4.4	3.5	3.0	n.a	11.5	3.2	2.3	1.7	n.a
Slovak Republic	4.7	n.a	2.2	1.9	n.a	0.8	n.a	-0.7	-0.3	n.a
Spain	10.5	6.4	5.3	4.8	2.0	8.1	4.0	3.3	3.0	1.3
Sweden	7.1	5.6	5.0	n.a	2.6	6.2	4.2	3.4	n.a	1.4
United Kingdom	6.5	4.9	4.1	3.8	2.3	7.5	5.7	4.4	3.7	1.7
EU15 average	*8.3*	*5.5*	*4.7*	*4.3*	*2.4*	*7.7*	*4.4*	*3.5*	*2.9*	*1.6*
Japan	14.4	10.6	9.1	8.3	4.7	12.4	8.1	6.6	5.9	3.1
Memo item:										
OECD average	*9.1*	*5.3*	*4.4*	*4.0*	*2.3*	*8.2*	*4.2*	*3.2*	*2.6*	*1.5*

1. 1960 (or 1961) to 2000 (or 1999).
Source : OECD Health Data.

Table 1.2. Comparison of past with projected gains in life expectancy

In number of years per decade

	(A) average gains 1960-2000	(B) projected gains 2000-2050[1]	Difference (B)-(A)
United States	1.7	1.4	-0.3
Europe			
Austria	2.4	1.4	-1.1
Belgium	1.8	1.6	-0.2
Czech Republic	1.1	1.3	0.2
Denmark	1.1	1.1	-0.1
Finland	2.2	1.5	-0.7
France	2.2	1.8	-0.4
Germany	2.0	1.2	-0.8
Greece	2.1	0.8	-1.3
Hungary	0.9	1.6	0.7
Ireland	1.7	0.9	-0.8
Italy	2.4	1.8	-0.6
Luxembourg	2.2	1.1	-1.1
Netherlands	1.1	0.5	-0.6
Poland	1.5	2.0	0.4
Portugal	3.1	1.1	-2.0
Slovak Republic	0.7	1.5	0.8
Spain	2.3	0.8	-1.5
Sweden	1.7	0.9	-0.7
United Kingdom	1.8	1.6	-0.2
EU15 average	*2.0*	*1.2*	*-0.8*
Japan	3.4	0.8	-2.6
Memo item:			
OECD average	*2.2*	*1.2*	*-0.9*

1. Except for Spain 2026, for Finland, Italy, Poland and United Kingdom 2030.
Source: OECD/DELSA Population database and OECD Health Data.

Table 2.1 Explaining Health Expenditure growth, France

Variation 1992-2000 (%)	Pharmaceutical expenditures	Total expenditures
Total demographic change of which: *part of structural change* *part of growing size of population*	**7.63** *4.61* *3.02*	**6.35** *3.36* *2.99*
Changes in practices for a given morbidity	**52.24**	**12.87**
Changes in morbidity	**- 9.24**	**- 9.74**
Changes in age dummies	14.11	-1.55
Other changes	2.53	45.95
Total variation	**67.27**	**53.89**

Source: Dormont, Grignon & Huber (2006)

Table2.2 Micro simulation results for three technologies by the Future Elderly Model.

	Intraventricular cardio defibrillator	**Prevention of Alzheimer's**	**Compound that extends life span (mythical)**
Annual cost	$ 37,500	$720	$ 365
Population concerned	50 % AMI patients	100 % Medicare recipients	100 % Medicare recipients
Potential effect	Decrease in mortality rate : 10 %	Delay of 3 years in incidence => decrease in prevalence of 1/3	Increase in life expectancy: +10 years
Cost of one year of life saved	$ 100,000	$ 80,300	$ 8,800
Increase in total Spending for *Medicare in 2030*	+ 3.7 %	+ 8.0 %	+ 13.8 % if healthy + 70.4 % if unhealthy

Source : Goldman *et al.* (2005)

Table 2.3 Estimated marginal cost of saving a life

Age	1950	1980	2000	Robust maximum, 2000	Per year of life saved, 2000	Growth rate, 1950–2000
0–4	10	160	590	(790)	8	7.8
10–14	270	2,320	9,830	(13,110)	152	7.2
20–24	1,170	3,840	8,520	(11,360)	155	4.0
30–34	500	2,120	4,910	(6,540)	108	4.6
40–44	160	740	1,890	(2,520)	52	4.9
50–54	70	330	1,050	(1,400)	39	5.4
60–64	50	280	880	(1,180)	47	5.9
70–74	40	280	790	(1,050)	67	6.2
80–84	40	340	750	(1,000)	125	6.1
90–94	50	420	820	(1,090)	379	5.6

Source: Hall and Jones (2007)

Table 3.1: Pooled OLS regressions --- Per capita public health expenditures

Variable	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[6]	[1]	[2]	[3]	[4]	[6]
Per capita GDP	1.661	1.649	1.428	1.443		1.48	1.342	1.314	1.331	1.341	1.557	1.441	1.406	1.421	1.406
	[0.000]	[0.000]	[0.000]	[0.000]		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Trend		0.002	0.011				0.007	0.001				0.005	0.002		
		[0.168]	[0.000]				[0.000]	[0.289]				[0.000]	[0.161]		
Trend 70-79				-0.002					0.011	0.009				0.01	0.009
				[0.785]					[0.056]	[0.015]				[0.054]	[0.023]
Trend 80-89				-0.002					0.005					0.006	
				[0.657]					[0.230]					[0.188]	
Trend 90-99				0.009					0					0.001	
				[0.000]					[0.872]					[0.801]	
POPY			0.762	0.164				-1.561	-1.823	-1.389			-1.178	-1.472	-1.182
			[0.000]	[0.371]				[0.000]	[0.000]	[0.000]			[0.000]	[0.000]	[0.000]
POPP			0.278	-0.217				-4.067	-4.514	-2.645			-3.337	-3.813	-2.343
			[0.417]	[0.459]				[0.000]	[0.000]	[0.000]			[0.000]	[0.000]	[0.000]
POPO			1.332	0.881				-1.231	-1.469	-0.996			-0.836	-1.101	-0.792
			[0.000]	[0.000]				[0.000]	[0.000]	[0.000]			[0.000]	[0.000]	[0.000]
Gatekeeping										-0.016					-0.017
										[0.294]					[0.260]
Public System										-0.093					-0.093
										[0.000]					[0.000]
Integrated System										0.116					0.107
										[0.000]					[0.000]
Observations	773	773	773	773		614	614	614	614	614	557	557	557	557	557
Countries	30	30	30	30		19	19	19	19	19	17	17	17	17	17

Note: p-value in [].

Table 3.2: Pooled OLS regressions --- Per capita private health expenditures

Variable	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[7]	[1]	[2]	[3]	[4]	[6]
Per capita GDP	1.084	0.962	1.124	1.138	1.136	1.159	0.678	0.527	0.634	1.012	1.459	1.117	1.034	1.121	1.291
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Trend		0.017	0.007				0.023	0.019				0.016	0.018		0.025
		[0.001]	[0.000]				[0.000]	[0.000]				[0.000]	[0.000]		[0.000]
Trend 70-79				-0.018	-0.016				-0.024	-0.031				-0.026	
				[0.000]	[0.000]				[0.000]	[0.000]				[0.000]	
Trend 80-89				-0.008					-0.014					-0.014	
				[0.053]					[0.061]					[0.033]	
Trend 90-99				0.005					0.016					0.013	
				[0.163]					[0.075]					[0.107]	
POPY			-0.791	-1.014	-1.076			-0.343	-1.462	-2.305			1.646	0.769	1.305
			[0.014]	[0.000]	[0.000]			[0.000]	[0.000]	[0.000]			[0.000]	[0.047]	[0.000]
POPP			0.387	0.204	0.137			2.651	0.991	-5.609			2.471	2.284	1.348
			[0.629]	[0.788]	[0.854]			[0.000]	[0.288]	[0.000]			[0.000]	[0.000]	[0.029]
POPO			-1.213	-1.392	-1.434			-1.333	-2.342	-3.935			0.967	0.191	-0.045
			[0.000]	[0.000]	[0.000]			[0.000]	[0.000]	[0.000]			[0.006]	[0.624]	[0.847]
Gatekeeping										-0.337					-0.309
										[0.000]					[0.000]
Public System										-0.462					-0.206
										[0.000]					[0.000]
Integrated System										-0.734					-0.736
										[0.000]					[0.000]
Observations	773	773	773	773		614	614	614	614	614	557	557	557	557	557
Countries	30	30	30	30		19	19	19	19	19	17	17	17	17	17

Table 3.3: Pooled OLS regressions --- Per capita total health expenditures

Variable	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[7]	[1]	[2]	[3]	[4]	[6]
Per capita GDP	1.471	1.426	1.345	1.358		1.441	1.269	1.243	1.277	1.311	1.559	1.459	1.456	1.481	1.502
	[0.000]	[0.000]	[0.000]	[0.000]		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Trend		0.007	0.008				0.008	0.005		0.005		0.004	0.004		0.006
		[0.000]	[0.000]				[0.000]	[0.000]		[0.000]		[0.000]	[0.000]		[0.000]
Trend 70-79				-0.002					0.004					0.002	
				[0.734]					[0.396]					[0.518]	
Trend 80-89				-0.001					0.003					0.002	
				[0.971]					[0.341]					[0.416]	
Trend 90-99				0.008					0.003					0.003	
				[0.001]					[0.223]					[0.265]	
POPY			0.087	-0.403				-0.997	-1.415	-0.909			-0.093	-0.451	-0.091
			[0.164]	[0.003]				[0.000]	[0.000]	[0.000]			[0.438]	[0.000]	[0.512]
POPP			-0.14	-0.526				-2.215	-2.898	-2.652			-0.268	-0.814	-1.062
			[0.271]	[0.001]				[0.000]	[0.000]	[0.000]			[0.343]	[0.001]	[0.002]
POPO			0.318	-0.051				-1.104	-1.414	-1.111			-0.032	-0.353	-0.179
			[0.000]	[0.668]				[0.000]	[0.000]	[0.000]			[0.810]	[0.001]	[0.000]
Gatekeeping										-0.119					-0.102
										[0.000]					[0.000]
Public System										-0.171					-0.104
										[0.000]					[0.000]
Integrated System										-0.101					-0.109
										[0.000]					[0.000]
Observations	773	773	773	773		614	614	614	614	614	557	557	557	557	557
Countries	30	30	30	30		19	19	19	19	19	17	17	17	17	17

Table 3.4: One-way fixed effects regressions in the individual dimension --- Per capita public health expenditures

Variable	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[6]
Per capita GDP	1.591	0.936	0.698	1.234		1.551	0.933	0.884	1.255	1.256	1.597	1.017	0.931	1.319	1.318
	[0.000]	[0.000]	[0.000]	[0.000]		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Trend		0.017	0.021				0.015	0.013				0.014	0.014		
		[0.000]	[0.000]				[0.000]	[0.116]				[0.000]	[0.000]		
Trend 70-79				0.002					0.009	0.009				0.009	0.008
				[0.692]					[0.101]	[0.081]				[0.102]	[0.098]
Trend 80-89				-0.001					0.002					0.002	
				[0.599]					[0.610]					[0.455]	
Trend 90-99				0.003					0.001					0.002	
				[0.013]					[0.532]					[0.447]	
POPY			1.074	0.123				0.175	-0.638	-0.645			0.241	-0.532	-0.537
			[0.000]	[0.529]				[0.111]	[0.000]	[0.000]			[0.000]	[0.000]	[0.000]
POPP			3.704	2.416				1.357	-0.038	-0.013			1.347	-0.058	-0.013
			[0.000]	[0.000]				[0.000]	[0.910]	[0.970]			[0.000]	[0.866]	[0.971]
POPO			1.668	1.114				0.814	0.272	0.273			0.858	0.325	0.329
			[0.000]	[0.000]				[0.000]	[0.023]	[0.023]			[0.000]	[0.006]	[0.006]
Gatekeeping															
Public System															
Integrated System															
Observations	773	773	773	773		614	614	614	614	614	557	557	557	557	557
Countries	30	30	30	30		19	19	19	19	19	17	17	17	17	17

Table 3.5: One-way fixed effects regressions in the individual dimension --- Per capita private health expenditures

Variable	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Per capita GDP	1.612	0.903	1.053	1.379		1.681	0.926	0.935	1.396	1.454	1.745	0.982	1.026	1.527	
	[0.000]	[0.000]	[0.000]	[0.000]		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	
Trend		0.018	0.015				0.019	0.019				0.018	0.019		
		[0.001]	[0.000]				[0.000]	[0.000]				[0.000]	[0.000]		
Trend 70-79				-0.013					-0.017	-0.015				-0.019	
				[0.001]					[0.000]	[0.000]				[0.000]	
Trend 80-89				-0.007					-0.005					-0.006	
				[0.011]					[0.049]					[0.070]	
Trend 90-99				0.007					0.007					0.009	
				[0.054]					[0.051]					[0.071]	
POPY			-0.905	-1.456				-0.612	-1.349	-1.412			-0.406	-1.021	
			[0.000]	[0.000]				[0.001]	[0.000]	[0.000]			[0.022]	[0.000]	
POPP			-2.224	-2.997				-1.69	-2.978	-3.274			-1.351	-2.56	
			[0.000]	[0.000]				[0.000]	[0.000]	[0.000]			[0.009]	[0.000]	
POPO			-1.619	-1.981				-1.506	-2.024	-2.103			-1.351	-1.806	
			[0.000]	[0.013]				[0.000]	[0.000]	[0.000]			[0.000]	[0.486]	
Gatekeeping															
Public System															
Integrated System															
Observations	773	773	773	773		614	614	614	614	614	557	557	557	557	557
Countries	30	30	30	30		19	19	19	19	19	17	17	17	17	17

Table 3.6: One-way fixed effects regressions in the individual dimension --- Per capita total health expenditures

Variable	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Per capita GDP	1.554	0.863	0.779	1.204		1.541	0.919	0.877	1.262		1.579	0.971	0.905	1.316	
	[0.000]	[0.000]	[0.000]	[0.000]		[0.000]	[0.000]	[0.000]	[0.000]		[0.000]	[0.000]	[0.000]	[0.000]	
Trend		0.018	0.017				0.015	0.014				0.015	0.014		
		[0.000]	[0.000]				[0.000]	[0.000]				[0.000]	[0.000]		
Trend 70-79				0.003					0.004					0.004	
				[0.452]					[0.285]					[0.382]	
Trend 80-89				-0.001					0.001					0.001	
				[0.939]					[0.651]					[0.599]	
Trend 90-99				0.004					0.003					0.003	
				[0.001]					[0.204]					[0.114]	
POPY			0.039	-0.765				0.098	-0.684				0.194	-0.552	
			[0.686]	[0.000]				[0.275]	[0.000]				[0.049]	[0.000]	
POPP			0.887	-0.215				0.981	-0.397				1.048	-0.332	
			[0.008]	[0.511]				[0.000]	[0.173]				[0.000]	[0.262]	
POPO			0.361	-0.093				0.477	-0.048				0.581	0.058	
			[0.002]	[0.453]				[0.000]	[0.655]				[0.000]	[0.596]	
Gatekeeping															
Public System															
Integrated System															
Observations	773	773	773	773		614	614	614	614	614	557	557	557	557	557
Countries	30	30	30	30		19	19	19	19	19	17	17	17	17	17

Table 3.7: Two-way fixed effects regressions

	Per capita public health expenditures						Per capita private health expenditures						Per capita total health expenditures					
Variable	[1]	[3]	[1]	[3]	[1]	[3]	[1]	[3]	[1]	[3]	[1]	[3]	[1]	[3]	[1]	[3]	[1]	[3]
Per capita GDP	0.952	0.719	0.927	0.935	0.972	0.967	0.921	1.047	0.976	0.969	1.089	1.131	0.876	0.814	0.917	0.923	0.949	0.944
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Trend																		
Trend 70-79																		
Trend 80-89																		
Trend 90-99																		
POPY		1.097		-0.068		-0.01		-0.973		-0.506		-0.255		0.081		-0.067		0.026
		[0.000]		[0.471]		[0.918]		[0.000]		[0.003]		[0.127]		[0.384]		[0.414]		[0.759]
POPP		3.308		-0.013		0.03		-1.857		-1.175		-0.958		0.531		-0.038		0.114
		[0.000]		[0.954]		[0.899]		[0.005]		[0.009]		[0.040]		[0.184]		[0.837]		[0.565]
POPO		1.716		0.504		0.544		-1.685		-1.388		-1.224		0.421		0.264		0.362
		[0.000]		[0.000]		[0.000]		[0.000]		[0.000]		[0.000]		[0.000]		[0.000]		[0.000]
Observations	773	773	614	614	557	557	773	773	614	614	557	557	773	773	614	614	557	557
Countries	30	30	19	19	17	17	30	30	19	19	17	17	30	30	19	19	17	17

Table 3.8: One-way error component model in the individual dimension --- Per capita public health expenditures

Variable	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[6]
Per capita GDP	1.591	1.121	0.913	1.266		1.547	0.981	0.971	1.269	0.992	1.596	1.074	1.045	1.345	1.053
	[0.000]	[0.000]	[0.000]	[0.000]		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Trend		0.013	0.016				0.014	0.011		0.01		0.013	0.011		0.011
		[0.000]	[0.000]				[0.000]	[0.000]		[0.000]		[0.000]	[0.000]		[0.000]
Trend 70-79				0.002					0.009					0.009	
				[0.412]					[0.000]					[0.001]	
Trend 80-89				-0.001					0.002					0.003	
				[0.606]					[0.395]					[0.274]	
Trend 90-99				0.003					0.001					0.002	
				[0.156]					[0.547]					[0.514]	
POPY			0.969	0.111				0.041	-0.697	0.027			0.138	-0.555	0.129
			[0.000]	[0.366]				[0.812]	[0.000]	[0.874]			[0.453]	[0.002]	[0.484]
POPP			3.247	2.102				0.896	-0.344	0.943			0.902	-0.294	0.958
			[0.000]	[0.000]				[0.046]	[0.438]	[0.035]			[0.053]	[0.526]	[0.040]
POPO			1.636	1.056				0.661	0.155	0.658			0.724	0.242	0.725
			[0.000]	[0.000]				[0.000]	[0.371]	[0.000]			[0.000]	[0.186]	[0.000]
Gatekeeping										0.015					0.009
										[0.857]					[0.922]
Public System										0.011					0.011
										[0.919]					[0.929]
Integrated System										0.184					0.181
										[0.003]					[0.008]
Observations	773	773	773	773		614	614	614	614	614	557	557	557	557	557
Countries	30	30	30	30		19	19	19	19	19	17	17	17	17	17

Note: The variance-covariance parameters are estimated by using the Swamy-Arora method.

Table 3.9: One-way error component model in the individual dimension --- Per capita private health expenditures

Variable	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Per capita GDP	1.599	0.938	1.102	1.379		1.675	0.913	0.918	1.379	0.922	1.745	0.987	1.023	1.515	1.035
	[0.000]	[0.000]	[0.000]	[0.000]		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Trend		0.018	0.014				0.019	0.02		0.019		0.018	0.019		0.019
		[0.000]	[0.000]				[0.000]	[0.000]		[0.000]		[0.000]	[0.000]		[0.000]
Trend 70-79				-0.013					-0.017					-0.019	
				[0.001]					[0.000]					[0.000]	
Trend 80-89				-0.007					-0.005					-0.006	
				[0.052]					[0.176]					[0.184]	
Trend 90-99				0.007					0.007					0.009	
				[0.042]					[0.107]					[0.049]	
POPY			-0.933	-1.456				-0.589	-1.351	-0.596			-0.376	-1.002	-0.369
			[0.000]	[0.000]				[0.063]	[0.000]	[0.060]			[0.262]	[0.001]	[0.270]
POPP			-2.292	-2.991				-1.585	-2.899	-1.677			-1.216	-2.415	-1.299
			[0.000]	[0.000]				[0.054]	[0.000]	[0.042]			[0.153]	[0.003]	[0.126]
POPO			-1.618	-1976				-1.489	-2.029	-1.517			-1.319	-1.778	-1.334
			[0.000]	[0.000]				[0.000]	[0.000]	[0.000]			[0.000]	[0.000]	[0.000]
Gatekeeping										-0.239					-0.245
										[0.518]					[0.379]
Public System										-0.361					-0.059
										[0.435]					[0.871]
Integrated System										-0.672					-0.662
										[0.010]					[0.002]
Observations	773	773	773	773		614	614	614	614	614	557	557	557	557	557
Countries	30	30	30	30		19	19	19	19	19	17	17	17	17	17

Table 3.10: One-way error component model in the individual dimension --- Per capita total health expenditures

Variable	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]
Per capita GDP	1.543	1.039	0.947	1.222		1.537	0.955	0.919	1.268	0.913	1.578	1.058	0.994	1.338	1.003
	[0.000]	[0.000]	[0.000]	[0.000]		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Trend		0.014	0.013				0.015	0.013		0.013		0.013	0.013		0.013
		[0.000]	[0.000]				[0.000]	[0.000]		[0.000]		[0.000]	[0.000]		[0.000]
Trend 70-79				0.003					0.004					0.003	
				[0.106]					[0.042]					[0.136]	
Trend 80-89				0					0.001					0.001	
				[0.998]					[0.563]					[0.544]	
Trend 90-99				0.004					0.003					0.003	
				[0.017]					[0.227]					[0.194]	
POPY			-0.038	-0.751				0.058	-0.697	0.03			0.169	-0.522	0.152
			[0.697]	[0.000]				[0.696]	[0.000]	[0.685]			[0.273]	[0.001]	[0.324]
POPP			0.591	-0.294				0.837	-0.486	0.846			0.879	-0.353	0.814
			[0.015]	[0.254]				[0.030]	[0.216]	[0.029]			[0.025]	[0.382]	[0.037]
POPO			0.343	-0.116				0.417	-0.102	0.421			0.879	0.034	0.503
			[0.000]	[0.199]				[0.006]	[0.503]	[0.005]			[0.001]	[0.831]	[0.001]
Gatekeeping										-0.031					-0.033
										[0.803]					[0.707]
Public System										0.014					0.087
										[0.924]					[0.453]
Integrated System										0.017					0.016
										[0.841]					[0.805]
Observations	773	773	773	773		614	614	614	614	614	557	557	557	557	557
Countries	30	30	30	30		19	19	19	19	19	17	17	17	17	17

Table 4.1 Projection of total Health Expenditures, scenario I

Residual at 1% per year (with no transversality condition) and income elasticity 1

	Health expenditure as a % of GDP		Death-related costs	Pure age effect (survivors)	Adjustment for healthy ageing	Income effect	Non-ageing residual effect	Total	Death-related costs	Pure age effect (survivors)	Adjustment for healthy ageing	Income effect	Non-ageing residual effect	Total	Health expenditure as a % of GDP
	2000	2005	Increase in % points of GDP 2005-2025						Increase in % points of GDP 2005-2050						2050
United States	12.0	14.3	0.1	0.8	-0.5	0.0	1.7	2.1	0.1	1.1	-1.0	0.0	4.4	4.7	19.0
Europe															
Austria	8.1	8.3	0.1	0.8	-0.6	0.0	1.7	2.1	0.2	1.9	-1.3	0.0	4.4	5.2	13.4
Belgium	7.2	9.4	0.1	0.7	-0.7	0.0	1.7	1.7	0.1	1.3	-1.3	0.0	4.4	4.5	13.9
Czech Republic	6.4	7.1	0.1	1.0	-0.6	0.0	1.7	2.3	0.2	2.3	-1.3	0.0	4.4	5.6	12.7
Denmark	5.8	6.3	0.1	0.7	-0.6	0.0	1.7	2.0	0.1	1.1	-0.8	0.0	4.4	4.8	11.1
Finland	4.2	4.8	0.1	1.2	-0.6	0.0	1.7	2.4	0.2	1.6	-1.3	0.0	4.4	4.9	9.8
France	7.9	9.3	0.1	0.9	-0.7	0.0	1.7	2.0	0.2	1.7	-1.5	0.0	4.4	4.8	14.0
Germany	9.0	9.3	0.1	0.8	-0.6	0.0	1.7	2.0	0.2	1.4	-1.1	0.0	4.4	4.9	14.2
Greece	9.3	9.4	0.1	0.7	-0.4	0.0	1.7	2.1	0.2	1.4	-0.8	0.0	4.4	5.3	14.7
Hungary	6.8	7.9	0.1	1.0	-0.8	0.0	1.7	2.1	0.2	1.9	-1.6	0.0	4.4	4.9	12.8
Ireland	5.7	6.6	0.1	0.7	-0.3	0.0	1.7	2.2	0.2	1.8	-1.0	0.0	4.4	5.5	12.1
Italy	7.1	7.7	0.1	1.0	-0.7	0.0	1.7	2.1	0.2	2.2	-1.8	0.0	4.4	5.1	12.8
Luxembourg	4.4	6.5	0.1	0.5	-0.5	0.0	1.7	1.8	0.2	1.3	-0.8	0.0	4.4	5.1	11.6
Netherlands	6.5	7.8	0.1	0.9	-0.4	0.0	1.7	2.3	0.1	1.1	-0.5	0.0	4.4	5.2	13.0
Poland	5.3	6.3	0.1	1.5	-0.8	0.0	1.7	2.5	0.2	3.0	-2.1	0.0	4.4	5.6	11.9
Portugal	8.8	9.6	0.1	0.9	-0.6	0.0	1.7	2.1	0.2	2.2	-1.1	0.0	4.4	5.7	15.3
Slovak Republic	5.2	5.8	0.1	1.4	-0.8	0.0	1.7	2.5	0.3	3.1	-1.6	0.0	4.4	6.2	12.0
Spain	6.6	7.6	0.1	0.7	-0.4	0.0	1.7	2.2	0.2	1.8	-0.8	0.0	4.4	5.6	13.2
Sweden	5.5	6.1	0.1	0.5	-0.4	0.0	1.7	1.9	0.1	0.6	-0.8	0.0	4.4	4.4	10.5
United Kingdom	5.9	6.8	0.1	0.8	-0.7	0.0	1.7	1.9	0.2	1.4	-1.2	0.0	4.4	4.8	11.7
EU15 average	*6.8*	*7.7*	*0.1*	*0.8*	*-0.5*	*0.0*	*1.7*	*2.1*	*0.2*	*1.5*	*-1.1*	*0.0*	*4.4*	*5.1*	*12.8*
Japan	6.8	7.4	0.1	1.2	-0.4	0.0	1.7	2.6	0.2	1.9	-0.7	0.0	4.4	5.8	13.2

NB: Assumptions used in this scenario:
Healthy ageing : dynamic equilibrium (1 year gains in life expectancy = 1 year in good health)
Income elasticity = 1
Residuals = 1 with no transversality condition
Source : Oliveira Martins and de la Maisonneuve (2006) and author's calculations.

Table 4.2 Projection for Total Health care Expenditures, scenario II

Residual at 1% per year (with no transversality condition) and income elasticity 1.5

	Health expenditure as a % of GDP		Death-related costs	Pure age effect (survivors)	Adjustment for healthy ageing	Income effect	Non-ageing residual effect	Total	Death-related costs	Pure age effect (survivors)	Adjustment for healthy ageing	Income effect	Non-ageing residual effect	Total	Health expenditure as a % of GDP
	2000	2005	Increase in % points of GDP 2005-2025						Increase in % points of GDP 2005-2050						2050
United States	12.0	14.3	0.1	0.8	-0.5	1.6	1.7	3.7	0.1	1.1	-1.0	3.8	4.4	8.5	22.8
Europe															
Austria	8.1	8.3	0.1	0.8	-0.6	1.4	1.7	3.5	0.2	1.9	-1.3	3.1	4.4	8.3	16.6
Belgium	7.2	9.4	0.1	0.7	-0.7	1.4	1.7	3.2	0.1	1.3	-1.3	3.4	4.4	7.9	17.2
Czech Republic	6.4	7.1	0.1	1.0	-0.6	0.9	1.7	3.2	0.2	2.3	-1.3	1.9	4.4	7.6	14.6
Denmark	5.8	6.3	0.1	0.7	-0.6	1.4	1.7	3.4	0.1	1.1	-0.8	3.5	4.4	8.3	14.6
Finland	4.2	4.8	0.1	1.2	-0.6	2.0	1.7	4.4	0.2	1.6	-1.3	4.3	4.4	9.3	14.1
France	7.9	9.3	0.1	0.9	-0.7	1.1	1.7	3.0	0.2	1.7	-1.5	2.8	4.4	7.6	16.9
Germany	9.0	9.3	0.1	0.8	-0.6	1.0	1.7	3.0	0.2	1.4	-1.1	2.8	4.4	7.7	17.0
Greece	9.3	9.4	0.1	0.7	-0.4	2.1	1.7	4.2	0.2	1.4	-0.8	3.8	4.4	9.0	18.4
Hungary	6.8	7.9	0.1	1.0	-0.8	2.2	1.7	4.3	0.2	1.9	-1.6	4.4	4.4	9.3	17.2
Ireland	5.7	6.6	0.1	0.7	-0.3	4.2	1.7	6.4	0.2	1.8	-1.0	6.9	4.4	12.4	19.0
Italy	7.1	7.7	0.1	1.0	-0.7	1.1	1.7	3.2	0.2	2.2	-1.8	2.5	4.4	7.6	15.3
Luxembourg	4.4	6.5	0.1	0.5	-0.5	3.3	1.7	5.1	0.2	1.3	-0.8	5.7	4.4	10.7	17.2
Netherlands	6.5	7.8	0.1	0.9	-0.4	1.3	1.7	3.7	0.1	1.1	-0.5	3.5	4.4	8.7	16.5
Poland	5.3	6.3	0.1	1.5	-0.8	3.4	1.7	5.9	0.2	3.0	-2.1	6.4	4.4	12.0	18.2
Portugal	8.8	9.6	0.1	0.9	-0.6	2.0	1.7	4.1	0.2	2.2	-1.1	3.7	4.4	9.4	19.0
Slovak Republic	5.2	5.8	0.1	1.4	-0.8	1.6	1.7	4.1	0.3	3.1	-1.6	2.8	4.4	9.0	14.8
Spain	6.6	7.6	0.1	0.7	-0.4	1.1	1.7	3.3	0.2	1.8	-0.8	2.7	4.4	8.3	15.9
Sweden	5.5	6.1	0.1	0.5	-0.4	1.6	1.7	3.6	0.1	0.6	-0.8	4.0	4.4	8.4	14.5
United Kingdom	5.9	6.8	0.1	0.8	-0.7	1.6	1.7	3.6	0.2	1.4	-1.2	3.8	4.4	8.6	15.4
EU15 average	*6.8*	*7.7*	*0.1*	*0.8*	*-0.5*	*1.8*	*1.7*	*3.8*	*0.2*	*1.5*	*-1.1*	*3.8*	*4.4*	*8.8*	*16.5*
Japan	6.8	7.4	0.1	1.2	-0.4	0.8	1.7	3.5	0.2	1.9	-0.7	2.5	4.4	8.3	15.7

NB: Assumptions used in this scenario:
Healthy ageing : dynamic equilibrium (1 year gains in life expectancy = 1 year in good health)
Income elasticity = 1.5
Residuals = 1 with no transversality condition
Source : Oliveira Martins and de la Maisonneuve (2006) and author's calculations.

Table 4.3 Projection for Total Health Expenditures, scenario III

Residual at 2% per year (with no transversality condition) and income elasticity 1

	Health expenditure as a % of GDP		Death-related costs	Pure age effect (survivors)	Adjustment for healthy ageing	Income effect	Non-ageing residual effect	Total	Death-related costs	Pure age effect (survivors)	Adjustment for healthy ageing	Income effect	Non-ageing residual effect	Total	Health expenditure as a % of GDP
	2000	2005	Increase in % points of GDP 2005-2025						Increase in % points of GDP 2005-2050						2050
United States	12.0	14.3	0.1	0.8	-0.5	0.0	3.8	4.2	0.1	1.1	-1.0	0.0	11.4	11.6	25.9
Europe															
Austria	8.1	8.3	0.1	0.8	-0.6	0.0	3.8	4.2	0.2	1.9	-1.3	0.0	11.4	12.1	20.4
Belgium	7.2	9.4	0.1	0.7	-0.7	0.0	3.8	3.9	0.1	1.3	-1.3	0.0	11.4	11.5	20.8
Czech Republic	6.4	7.1	0.1	1.0	-0.6	0.0	3.8	4.4	0.2	2.3	-1.3	0.0	11.4	12.6	19.7
Denmark	5.8	6.3	0.1	0.7	-0.6	0.0	3.8	4.1	0.1	1.1	-0.8	0.0	11.4	11.8	18.1
Finland	4.2	4.8	0.1	1.2	-0.6	0.0	3.8	4.5	0.2	1.6	-1.3	0.0	11.4	11.9	16.7
France	7.9	9.3	0.1	0.9	-0.7	0.0	3.8	4.1	0.2	1.7	-1.5	0.0	11.4	11.7	21.0
Germany	9.0	9.3	0.1	0.8	-0.6	0.0	3.8	4.1	0.2	1.4	-1.1	0.0	11.4	11.9	21.1
Greece	9.3	9.4	0.1	0.7	-0.4	0.0	3.8	4.3	0.2	1.4	-0.8	0.0	11.4	12.2	21.6
Hungary	6.8	7.9	0.1	1.0	-0.8	0.0	3.8	4.2	0.2	1.9	-1.6	0.0	11.4	11.8	19.7
Ireland	5.7	6.6	0.1	0.7	-0.3	0.0	3.8	4.3	0.2	1.8	-1.0	0.0	11.4	12.4	19.0
Italy	7.1	7.7	0.1	1.0	-0.7	0.0	3.8	4.2	0.2	2.2	-1.8	0.0	11.4	12.0	19.8
Luxembourg	4.4	6.5	0.1	0.5	-0.5	0.0	3.8	3.9	0.2	1.3	-0.8	0.0	11.4	12.0	18.5
Netherlands	6.5	7.8	0.1	0.9	-0.4	0.0	3.8	4.4	0.1	1.1	-0.5	0.0	11.4	12.1	19.9
Poland	5.3	6.3	0.1	1.5	-0.8	0.0	3.8	4.6	0.2	3.0	-2.1	0.0	11.4	12.5	18.8
Portugal	8.8	9.6	0.1	0.9	-0.6	0.0	3.8	4.2	0.2	2.2	-1.1	0.0	11.4	12.7	22.3
Slovak Republic	5.2	5.8	0.1	1.4	-0.8	0.0	3.8	4.6	0.3	3.1	-1.6	0.0	11.4	13.2	19.0
Spain	6.6	7.6	0.1	0.7	-0.4	0.0	3.8	4.3	0.2	1.8	-0.8	0.0	11.4	12.5	20.2
Sweden	5.5	6.1	0.1	0.5	-0.4	0.0	3.8	4.0	0.1	0.6	-0.8	0.0	11.4	11.3	17.4
United Kingdom	5.9	6.8	0.1	0.8	-0.7	0.0	3.8	4.0	0.2	1.4	-1.2	0.0	11.4	11.8	18.6
EU15 average	*6.8*	*7.7*	*0.1*	*0.8*	*-0.5*	*0.0*	*3.8*	*4.2*	*0.2*	*1.5*	*-1.1*	*0.0*	*11.4*	*12.0*	*19.7*
Japan	6.8	7.4	0.1	1.2	-0.4	0.0	3.8	4.7	0.2	1.9	-0.7	0.0	11.4	12.8	20.2

NB: Assumptions used in this scenario:
Healthy ageing : dynamic equilibrium (1 year gains in life expectancy = 1 year in good health)
Income elasticity = 1
Residuals = 2 with no transversality condition
Source : Oliveira Martins and de la Maisonneuve (2006) and author's calculations.

Table 4.4 Projection for Total Health care expenditures, scenario IV

Residual at 1% per year (with a transversality condition), income elasticity 1 and expansion of morbidity

	Health expenditure as a % of GDP		Death-related costs	Pure age effect (survivors)	Adjustment for healthy ageing	Income effect	Non-ageing residual effect	Total	Death-related costs	Pure age effect (survivors)	Adjustment for healthy ageing	Income effect	Non-ageing residual effect	Total	Health expenditure as a % of GDP
	2000	2005	Increase in % points of GDP 2005-2025						Increase in % points of GDP 2005-2050						2050
United States	12.0	14.3	0.1	0.8	0.0	0.0	1.3	2.2	0.1	1.1	0.0	0.0	1.9	3.2	17.5
Europe															
Austria	8.1	8.3	0.1	0.8	0.0	0.0	1.3	2.2	0.2	1.9	0.0	0.0	1.9	4.0	12.2
Belgium	7.2	9.4	0.1	0.7	0.0	0.0	1.3	2.0	0.1	1.3	0.0	0.0	1.9	3.3	12.7
Czech Republic	6.4	7.1	0.1	1.0	0.0	0.0	1.3	2.4	0.2	2.3	0.0	0.0	1.9	4.4	11.5
Denmark	5.8	6.3	0.1	0.7	0.0	0.0	1.3	2.1	0.1	1.1	0.0	0.0	1.9	3.1	9.4
Finland	4.2	4.8	0.1	1.2	0.0	0.0	1.3	2.6	0.2	1.6	0.0	0.0	1.9	3.7	8.5
France	7.9	9.3	0.1	0.9	0.0	0.0	1.3	2.2	0.2	1.7	0.0	0.0	1.9	3.8	13.0
Germany	9.0	9.3	0.1	0.8	0.0	0.0	1.3	2.2	0.2	1.4	0.0	0.0	1.9	3.5	12.8
Greece	9.3	9.4	0.1	0.7	0.0	0.0	1.3	2.1	0.2	1.4	0.0	0.0	1.9	3.5	12.9
Hungary	6.8	7.9	0.1	1.0	0.0	0.0	1.3	2.4	0.2	1.9	0.0	0.0	1.9	4.0	11.9
Ireland	5.7	6.6	0.1	0.7	0.0	0.0	1.3	2.1	0.2	1.8	0.0	0.0	1.9	3.9	10.5
Italy	7.1	7.7	0.1	1.0	0.0	0.0	1.3	2.4	0.2	2.2	0.0	0.0	1.9	4.4	12.1
Luxembourg	4.4	6.5	0.1	0.5	0.0	0.0	1.3	1.9	0.2	1.3	0.0	0.0	1.9	3.4	9.9
Netherlands	6.5	7.8	0.1	0.9	0.0	0.0	1.3	2.3	0.1	1.1	0.0	0.0	1.9	3.2	11.0
Poland	5.3	6.3	0.1	1.5	0.0	0.0	1.3	2.9	0.2	3.0	0.0	0.0	1.9	5.1	11.4
Portugal	8.8	9.6	0.1	0.9	0.0	0.0	1.3	2.3	0.2	2.2	0.0	0.0	1.9	4.3	13.9
Slovak Republic	5.2	5.8	0.1	1.4	0.0	0.0	1.3	2.9	0.3	3.1	0.0	0.0	1.9	5.3	11.1
Spain	6.6	7.6	0.1	0.7	0.0	0.0	1.3	2.1	0.2	1.8	0.0	0.0	1.9	3.9	11.5
Sweden	5.5	6.1	0.1	0.5	0.0	0.0	1.3	1.9	0.1	0.6	0.0	0.0	1.9	2.7	8.8
United Kingdom	5.9	6.8	0.1	0.8	0.0	0.0	1.3	2.2	0.2	1.4	0.0	0.0	1.9	3.5	10.3
EU15 average	*6.8*	*7.7*	*0.1*	*0.8*	*0.0*	*0.0*	*1.3*	*2.2*	*0.2*	*1.5*	*0.0*	*0.0*	*1.9*	*3.6*	*11.3*
Japan	6.8	7.4	0.1	1.2	0.0	0.0	1.3	2.6	0.2	1.9	0.0	0.0	1.9	4.0	11.4

NB: Assumptions used in this scenario:
Expansion of morbidity : gains in life expectancy do not translate into years in good health
Income elasticity = 1
Residuals = 1 with a transversality condition
Source : Oliveira Martins and de la Maisonneuve (2006) and author's calculations.

Table 5.1 The size of pharmaceutical markets (€ million)

	1999	2000	2001	2002	2003
EU-15	72,094	29,962	90,100	96,825	103,142
US	124,261	163,439	197,351	208,970	194,061
Japan	50,246	62,606	59,744	55,736	52,092

Source: European Commission (2006)

Table 5.2 Shares of USPTO-granted pharmaceutical patents by countries based on the nationality of the assignee (A) and location of the inventor (I)

	1974-1983			1984-1993			1994-2003		
	Assignee	Inventor	I-A	Assignee	Inventor	I-A	Assignee	Inventor	I-A
EU	28.3%	30.9%	2.6%	27.3%	29.2%	1.9%	23.1%	24.8%	1.7%
USA	59.0%	52.3%	-6.7%	55.2%	50.8%	-4.4%	60.1%	57.3%	-2.8%
Japan	9.3%	9.4%	0.2%	13.4%	13.6%	0.1%	9.2%	9.3%	0.2%

Source: EC (2006)

Table 5.3 Shares of patent citations of USPTO-granted pharmaceutical patents by countries based on the nationality of the assignee (A) and location of the inventor (I)

	1974-1983			1984-1993			1994-2003		
	Assignee	Inventor	I-A	Assignee	Inventor	I-A	Assignee	Inventor	I-A
EU	23.57%	25.50%	1.92%	19.43%	21.33%	1.90%	17.47%	19.06%	1.59%
USA	63.71%	59.33%	-4.38%	67.12%	63.52%	-3.60%	70.39%	68.13%	-2.26%
Japan	9.26%	8.99%	-0.27%	9.55%	9.64%	0.09%	6.00%	6.07%	0.07%

Source: EC (2006)

Table 5.4: Patent citations

	1974-1983	1984-1993	1994-2003
USA			
Patent count	8,943	14,860	36,271
Number of citations*(1)*	6,680	40,332	201,510
Mean number of citations	0.75	2.71	5.56
of which:			
US->US	74.70%	73.00%	74.70%
US->EU	18.29%	18.51%	18.82%
US->JP	5.09%	7.06%	6.77%
EU-25			
Patent count	5,238	8,525	1,5904
Number of citations*(1)*	3,153	15,004	46,396
Mean number of citations	0.60	1.76	2.92
of which:			
EU->EU	55.25%	51.18%	43.64%
EU->US	36.12%	38.83%	49.11%
EU->JP	5.49%	7.96%	7.49%
Japan			
Patent count	1,582	3,845	5,678
Number of citations*(1)*	959	5,833	11,746
Mean number of citations	0.61	1.52	2.07ì
of which:			
JP->JP	40.88%	36.57%	35.96%
JP->US	33.99%	37.68%	42.23%
JP->EU	23.46%	23.90%	22.26%

Source: EC (2006)