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Why Do Americans Spend So Much More on Health Care than Europeans?

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February 7, 2019

Abstract

Empirical evidence shows that both leisure and medical care are important in maintaining health. And taxation may affect the allocation of these two inputs. We build a life-cycle overlapping-generations model in which taxation and relative health care price are key determinants of the composition of the two inputs in the endogenous accumulation of health capital. In the model, a lower tax wedge leads to using relatively more medical care and less leisure in maintaining health, while a higher relative health care price implies an opposite substitution in quantity (away from medical care towards leisure) that weakens the direct bearing of the higher price on overall health spending. We show that differences in taxation and in relative health care price between the US and Europe can jointly account for a bulk of their differences in health expenditure-GDP ratio and in leisure time allocated for health production, with taxation channel playing a quantitatively more significant role.

JEL classifications: E2; E6; H2

Keywords: Macro-health; Taxation; Relative health care price; Health care expenditure; Time allocation; Life cycle; Overlapping generations

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1 Introduction

In the past thirty years or so, Americans persistently spend much more on medical care than Europeans. In one account, the average medical expenditure to GDP ratio over the period 1990-2015 is about 5.7 percentage point higher in the US than the average across eight comparably rich European countries, including Belgium, Finland, France, Germany, Italy, Netherlands, Spain, and the UK. Medical expenditure per capita is also much greater in the US than in Europe. As we will document in Section 2, the difference illustrated above is beyond the counting of the US-Europe difference in expenditure on health-related research and development and on education and training of health personnel, neither are there notable cross-country differences in the age structure of population or age-related medical status, with which the cross-country difference in medical expenditure-GDP ratio can be squared.

Then why do Americans spend so much more on health care than Europeans? We highlight a channel that has not received much attention in the literature on health care costs through the lens of a life-cycle overlapping-generations (OLG) model of health investment portfolio. We emphasize two forms of health investment: (1) medical goods and services, which are the usual focus in the economics literature and policy debate, and (2) health-enhancing leisure-time activity, which has received much less attention, even though, as we show below, ample empirical evidence reveals its importance in producing and maintaining health. The thesis of this paper is that these two inputs for health production must be jointly determined and that cross-country variations in the determinants of such portfolio composition of health investment can hold a key to understanding the cross-country differences in health care expenditure.

We show that one determinant of the composition of health investment portfolio is taxation, in particular, labor income and consumption taxes. Higher tax rates on consumption and labor income lead to using relatively more leisure and less medical care in producing and maintaining health. While labor income taxes are relevant for working age population, consumption taxes matter for both workers and retirees. We show the empirical relevance of the taxation channel and we use our life-cycle OLG macro-health model to quantify its importance.

The crucial and relevant fact then is that, for the same period that Europeans spend much less on health care than Americans, labor income and consumption tax rates are significantly higher in Europe than in the US, as we document in Section 2. We find that this difference in taxation can account for a significant fraction of the difference in medical expenditure-GDP ratio between the US and Europe.

This account of the US-Europe difference in medical expenditure is accompanied by a simultaneous prediction of our model on cross-country difference in leisure time input as another component of an optimal health investment portfolio. We wish to emphasize from the outset that this portfolio view of health investment is essential for our model's success stated above. Were we to abstract from time input in health production, as we will show below through a counterfactual experiment (Section 8.3), the explanation power of the model in predicting cross-country differences in health expenditures decreases significantly.

The important question then is whether our model's prediction on cross-country difference in time input for health production has any empirical support. The model predicts that, since labor and consumption tax rates are higher in Europe than in the US, Europeans would rely more on leisure than Americans when it comes to producing and maintaining health. As we will show below, this is indeed what is observed from the micro data on health-enhancing leisure time, whether broadly or narrowly defined. The model is able to show that the US-Europe difference in taxation can account for a significant portion of their difference in time input for health production.

These together suggest that difference in taxation can provide a coherent account of the US-Europe differences in the composition of health investment portfolio.

Another factor that may also affect health investment portfolio in an important way is the price of health care goods and services relative to the general price level. As we document below in Section 2, relative health care price on average is higher in the US than in Europe. In fact, such cross-country difference in relative health care price is often thought of as contributing significantly to the higher overall health spending by Americans than by Europeans (e.g., Squires 2012, Horenstein and Santos forthcoming). It is thus also fitting to examine the relative health care price effect viewed through the lens of our model on health investment portfolio.

Two countervailing effects on overall health spending arise from a higher relative price of medical care in our model: (1) higher spending per unit of medical consumption, and (2) substitution away from medical care towards other goods or leisure in generating utility and towards time input in producing and maintaining health. As we show below, in the baseline setting, the effect of (1) dominates that of (2), but it is partially offset by the latter. This is to say that the contribution of a higher relative health care price to higher overall health expenditure is weakened by the re-balancing of health investment portfolio. Moreover, this re-balancing implies that a higher relative health care price would lead to using relatively more time input and less medical commodity in producing and maintaining health. Thus, although the US-Europe difference in relative health care price may account for some of their difference in overall health expenditure-GDP ratio, its implication on time allocation is in a direction that is opposite to the data.

To see this last point more transparently, we fit into our model the cross-country distribution of relative health care prices observed from the US and European data, while keeping the cross-country difference in taxation muted. The result shows that, while the relative health care price difference can indeed explain a nontrivial fraction of the difference in overall health spending-GDP ratio between the US and Europe, even though significantly smaller than that explained by the taxation channel, it tends to make Europeans have longer paid work time and shorter leisure time allocated for health production when compared to Americans, whereas the opposite holds in the data.

When we turn on the US-Europe differences in taxation and in relative health care price at the same time, our model can account for a bulk of their difference in overall medical expenditure-GDP ratio and in time allocation. Hence differences in taxation and in relative health care price can jointly provide a reasonable account of the US-Europe difference in the composition of health investment portfolio in our baseline model.

The remaining of the paper is organized as follows. In Section 2, we document empirical evidence that motivates the present study and we review related literature. In Section 3, we use a simple theoretical model to qualitatively illustrate that a higher tax wedge can lead to smaller health expenditure and greater health-enhancing leisure time. Section 4 provides further empirical analysis to test the theoretical hypotheses developed in Section 3, using micro level cross-country time use surveys. In Section 5, we present our large-scale life-cycle overlapping-generations model for the quantitative analysis. In Section 6, we describe in details the calibration of the baseline model. Section 7 summarizes the quantitative results of the baseline model. Section 8 provides additional sensitivity analysis. Section 9 concludes the paper.

2 Empirical Evidence and Related Literature

It is a much publicized fact nowadays that Americans spend considerably more on health care than Europeans. In 2016, for instance, health care expenditure accounts for 17.1% of GDP in the US, compared with 10.0% in Belgium, 9.5% in Finland, 11.5% in France, 11.1% in Germany, 8.9% in Italy, 10.4% in Netherlands, 9.0% in Spain, and 9.8% in the UK. To a large extent, such differences have existed for quite some time. The first column of Table 1 reports the average health spending to GDP ratio over the period 1990-2015 for the US and the eight comparably rich European countries. As is apparent from the table, the US spends a much larger share of its GDP on health care over this period of time, when compared with the other countries. Health care expenditure per capita is also much greater in the US than in Europe.[1]

The differences in health care expenditure between the US and Europe illustrated above are not attributed to the US-EU differences in expenditure on health-related research and development, or on education and training of health personnel.[2] There also do not seem to exist notable cross-country differences in the age structure of population or age-related health status, to which the reported US-EU differences in health care expenditure can be attributed (e.g., Anderson and Hussey 2000; Gerdtham and Jonsson 2000; Peterson and Burton 2007; Pearson 2009, Squires 2012). This is consistent with the finding that health care expenditures are higher in the US than in many of the European countries not only on aggregate but also within different age groups.[3] In addition, the differences seem not driven by greater supply or utilization of hospitals and doctors (Squires 2012).

The point of departure of our analysis in this paper is to recast the issue of health care costs as a general equilibrium problem regarding the choice of health investment portfolio, of which the two crucial components are medical consumption and health-enhancing leisure-time activity. The idea that not only medical commodity but also leisure time are critical health inputs has been envisioned in several classic writings, such as Grossman (1972), Gronau (1977), and Ruhm (2000), which are accompanied by many supporting empirical studies. One of such empirical investigations is conducted by Sickles and Yazbeck (1998). Using a structural model to control for endogeneity and reverse causality, these authors estimate a trans-log production function of health, with both leisure time and medical commodity as inputs, based on US time series data. Their finding is that both inputs make significantly positive contributions to producing and maintaining health.[4] A recent econometric study

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[1] Source: OECD Health Data 2018.

[2] According to the OECD, total health care expenditure is defined as the sum of expenditures on activities that – through application of medical, paramedical, and nursing knowledge and technology – have the goals of: 1) Promoting health and preventing disease; 2) Curing illness and reducing premature mortality; 3) Caring for persons affected by chronic illness who require nursing care; 4) Caring for persons with health-related impairments, disability, and handicaps who require nursing care; 5) Assisting patients to die with dignity; 6) Providing and administering public health; 7) Providing and administering health programmes, health insurance and other funding arrangements. This definition does not include expenses on education and training of health personnel, research and development in health, food, hygiene and drinking water control, and environmental health. See http://stats.oecd.org/index.aspx for details.

[3] See, for example, Hagist and Kotlikoff (2009) for the European countries, and Jung and Tran (2010) for the US. See, also, Table 2 in Anderson and Hussey (2000).

[4] Corroborating evidence has also been found by Kenkel (1995), Contoyannis and Jones (2004), Scholz and Seshadri (2010), and Insler (2011), among others.

by He, Huang, and Hung (2013) presents consistent empirical evidence based on multi-country data.

Empirical evidence on the significant contribution of leisure to good health can also be found in the literatures of biomedical science, public health, psychobiology, and biosociology. While most of such studies in these literatures focus on identifying separately the specific health benefits of individual leisure activities,[5] some of these studies also show the evidence that increases in leisure time activities help reduce medical expenditures (e.g., Colditz 1999; Pratt *et al.* 2000; Wang and Brown 2004; Brown *et al.* 2005). The recent study by Pressman *et al.* (2009) establishes a general positive link between a wide variety of leisure activities (e.g., having hobbies, playing sports, socializing, spending time unwinding, spending time in nature, visiting friends or family, going on vacation, going to clubs or religious events) and a broad spectrum of health benefits (e.g., lower blood pressure, waist circumference, body mass index, and cortisol measurements, lower levels of stress and depression, stronger and better social networks, better feelings of satisfaction and engagement in lives, better sleep, better physical function and mood). Caldwell (2005), Russell (2009), and Payne *et al.* (2010) provide a comprehensive review of the empirical evidence on the importance of leisure in achieving and maintaining good health, and an intuitive account of the prevention, coping, and transcendence mechanisms through which leisure enhances physical, mental, social, and cognitive health.[6]

As discussed in the introduction section, one determinant of the composition of the two health inputs is taxation and, therefore, cross-country differences in labor income and consumption tax rates may hold a key to understanding cross-country differences in medical consumption, as well as in time input for health production. The linchpin of our analysis in this paper then has to do with the fact that, for the same period that Europeans spend much less on health care than Americans, labor income and consumption tax rates are much higher in Europe than in the US. This can be seen from the fifth to the seventh columns of Table 1, which report the average labor and consumption tax rates, along with the corresponding tax wedge, over the period 1990-2015 for the nine selected countries.[7] The tax wedge reported

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[5] For example, leisurely walking or cycling, exercising, vacationing, spending time in nature, engaging in social activities, having hobbies, proper sleep hygiene, and restorative activities have all been independently shown to improve physical, mental, social, or cognitive health. See He and Huang (2013) for a list of references.

[6] See He and Huang (2013) for a list of references.

[7] Source: McDaniel (2007) and its updates. The author applies the methodology in Mendoza *et al.* (1994) to calculate a variety of average tax rates over an extended period of time for a number of OECD countries, using national account statistics as a primary source. The data are downloaded from http://www.caramcdaniel.com/researchpapers.

in the seventh column of the table, of which the precise definition will be given in the next section, is a monotonically increasing function of the labor and consumption tax rates. As such, the tax wedge is much higher in Europe than in the US, as is clear from the table. Our model then predicts that Europeans may rely less on medical commodity and more on leisure than Americans when it comes to health production. The first part of this prediction is consistent with the observation from the US and European data, as reported above, whereby the second part of the prediction also conforms to the data, as we document below.

Empirical evidence shows that conventionally defined leisure time, as is measured by the time spent away from paid work, is much shorter, whereas measured hours of paid work are much longer, in the US than in most European countries. This fact is elaborated by Figure 1 in Jones and Klenow (2011). More formally, as can be seen from the second column of Table 1, Europeans on average spend 2.9% less of their time endowment on paid work, and thus 2.9% more of their time endowment is spent on leisure, when compared to Americans.[8] As a standard practice in the literature (e.g., Rogerson 2006; Ohanian *et al.* 2008; Jones and Klenow 2011), time spent on paid work is here calculated as annual hours per worker, divided by 360×16 to get a measure of paid work time as a percentage of annual discretionary time. Leisure time is then taken as the residual of paid work time following the conventional definition.

The US-EU differences in time allocation continue to hold even if we tease out unpaid work time (e.g., home production time) from the conventionally measured leisure time (i.e., the residual of paid work time). Based on national time-use surveys, which record how people allocate their time (typically using a 24-hour diary), OECD (2011) classifies time allocation by working age populations in 29 countries over the period 1998-2009 into *paid work or study*, *unpaid work*, *personal care*, *leisure*, and *other time use*, which, when averaged over the 29 countries, take up 19%, 14%, 46%, 20%, and 1% of the total time endowment, and which also show significant variations across the countries. The division between unpaid work and personal care, or leisure for that matter, is determined by the "third-person" criterion: If a third person could be hired to carry out the activity, while the benefits of the activity would still accrue to the hirer, then it is considered to be work. Under this criterion, cooking, cleaning, doing laundry, shopping, walking the dog, gardening, volunteering, and caring for children and other family and non-family members are all examples of unpaid work. In contrast, someone else cannot be paid on another's behalf to sleep, eat, drink, visit a doctor, watch a game, go to a concert, lay on the beach, jog, swim, play tennis, ride the treadmill, socialize with friends and family, attend a cultural event, read a book silently, or spend time unwinding, as the benefits of the activity would

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[8] The data are taken from Total Economy Database (TED) for the period 1990-2015.

accrue to the doer, but not to the hirer. Thus, these activities are all examples of *personal care* or *leisure*, which are arguably potential time inputs for the production of health.

The third column in Table 1 reports the sum of these two categories of time use, which we shall broadly refer to as potential time input in health production, or, with some abuse of terminology, leisure time for short, as a fraction of the time endowment for the nine selected OECD countries. As is apparent from the table, all of the eight European countries are much higher on this time input for health production when compared with the US, and the Eurozone average is about 4% higher than the America's. This is equivalent to saying that Europeans on average spend one hour more per day on potentially health-enhancing activities than Americans. And majority of that one-hour time comes from reducing paid work.

It is also much known nowadays that the prices of health care goods and services relative to the general price levels are generally higher in the US than in Europe (e.g., Anderson *et al.* 2003, Angrisano *et al.* 2007, Cutler and Ly 2011, Squires 2012, Horenstein and Santos forthcoming). This can be seen from the eighth column of Table 1, which reports the purchasing power parities-adjusted price indexes of health care goods and services relative to non-medical commodities for the nine selected countries in 2005. As is shown, for example, the price of health care is 20% higher than that of non-medical consumption in the US, while in Germany the price of health care is only 94% of that of non-medical consumption. This implies that the relative price of health care is about 26% higher in the US than in Germany. It can be inferred from the indexes reported in this column of the table that the relative price of health care in the US is about 16% higher than the European average. These indexes are constructed by He, Huang, and Hung (2013),[9] based on the data from the OECD 2005 PPP Benchmark Results, which is a widely used dataset for international comparison of relative prices for health care goods and services (e.g., Pearson 2009).[10]

Some recent studies suggest various cultural and institutional differences between the US and Europe as potentially relevant for their differences in hours worked.[11] These studies typically abstract from health-related issues. On the other hand, there is an emerging class of economic models featuring endogenous health accumulation,

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[9] In addition to constructing these relative price indexes, He, Huang, and Hung (2013) discuss some general issues concerning measures of data on prices and quantities (including time uses).

[10] Source of original data: http://stats.oecd.org/Index.aspx?DataSetCode=PPP2005. The data obtained here are broadly consistent with those from earlier studies, such as the individual country case studies on the price level of health care conducted by McKinsey Global Institute (1996).

[11] See He and Huang (2013) for a list of references.

which are developed to help understand the rising medical expenditure in the US (e.g., Suen 2006; Hall and Jones 2007; Fonseca *et al.* 2009; Zhao 2014), welfare effects of health care reforms (e.g., Feng 2008; Jung and Tran 2009), implications of health risks for consumption, health expenditure, and allocation of wealth among bonds, stocks, and housing (e.g., Yogo 2009), implications of employment-based health benefits in the US (e.g., Fang and Gavazza 2011; Huang and Huffman 2014), and the trade-off of provision of health-related social insurance on risk-sharing against dynamic disincentive ("moral hazard") effect of health investment (e.g., Cole, Kim, and Krueger forthcoming). These studies do not address cross-country difference in health care expenditure and they do not model time input in health production.

3 A Qualitative Illustration

We here use a simple static model to illustrate the main mechanism of the paper that taxation influences not only time allocation, but also health investment portfolio, or, the leisure time-medical goods consumption choice discussed in the introduction. The simple model also generates some testable hypotheses that will be further studied in our empirical analysis in the next section.

The economy consists of a representative household, a representative firm, and a government. The household chooses leisure time l, work time n, health-neutral consumption c, medical consumption m, and health stock h to maximize

$$U(c) + V(l) + \psi \log h$$

subject to

$$\begin{aligned} (1+\tau_c)(c+pm) &= (1-\tau_n)wn + T, \\ n + l &= 1, \\ h &= B\left(m^{\theta} l^{1-\theta}\right)^{\xi}, \end{aligned}$$

for some $\psi > 0$, $B > 0$, $\xi > 0$, and $\theta \in (0,1)$, where τ_c and τ_n denote consumption and labor income tax rates, respectively, w is the wage rate, p is the relative price of medical goods, and T is a lump-sum transfer from the government to the household. The functions U and V are strictly increasing and concave, and twice continuously differentiable. The feature that being healthier directly enhances household utility captures Grossman's (1972) notion of consumption motive for health investment. The other defining feature of the model is that health investment is created using both medical care and leisure time, as supported by the empirical studies of Sickles and Yazbeck (1998) and He, Huang, and Hung (2013).

The representative firm maximizes profit $y - wn$ based on a production function $y = An$, for some $A > 0$. The government runs a balanced budget and rebates all tax revenues to the household in the form of the non-distortionary lump-sum transfer, or, $\tau_c(c+pm)+\tau_n wn = T$. The goods market clearing condition requires $c+pm = y$.

To provide a general characterization of the model's equilibrium conditions, it is useful to define, in the spirit of Prescott (2004), a tax wedge as the sum of the tax rates on labor income and on consumption in units of the consumption goods,

$$\tau = \frac{\tau_n + \tau_c}{1 + \tau_c},$$

which is a monotonically increasing function of the labor and consumption tax rates.

We can combine the first order conditions for the household's utility maximization problem to obtain:

$$V'(l) + \frac{\psi(1-\theta)\xi}{l} = w(1-\tau)\frac{\psi\theta\xi}{pm}, \tag{1}$$

$$U'(c) = \frac{\psi\theta\xi}{pm}. \tag{2}$$

Equation (1) prescribes optimal time allocation and health investment portfolio. The left hand side of (1) is the total marginal utilities from additional leisure time, which is tax free, equal to the sum of the direct utility gain V' and the utility gain from the enhanced health (the second term on the left side of (1)) produced by the additional leisure time activity. If instead this additional time is devoted to market work, which is taxable, the resultant post-tax wage income can be used for medical consumption that also enhances health to yield utility gain. This is the right hand side of (1). Equation (1) implies that a greater tax wedge, by lowering the effective wage, which is the opportunity cost of leisure, would shift time allocation from work to leisure as well as re-balance health investment portfolio by using more leisure time activity and less medical expenditure for producing and maintaining health.

Equation (2) governs optimal consumption portfolio. The left hand side of (2) is the marginal utility from additional health-neutral consumption. If this is forgone, the saved income can be used for medical consumption that enhances health to yield marginal utility equal to the right hand side of (2). It is worth noting that the two types of consumption are subject to identical tax rate so the tax wedge is canceled out on both sides of (2).

Combining the household's and government's budget equations gives rise to the following economy-wide resource constraint:

$$c + pm = w(1-l). \tag{3}$$

Equations (1), (2) and (3) constitute a system of three equilibrium conditions for solving three endogenous variables, c, l, and m, which can be viewed as implicit functions of the tax wedge. Viewing (1), (2) and (3) as three identities about the tax wedge and applying the Implicit Function Theorem to totally differentiate their two sides with respect to τ, we obtain:

$$\begin{bmatrix} -w(1-\tau)U'' & V'' - \frac{\psi(1-\theta)\xi}{l^2} & 0 \\ -pU'' & 0 & -\frac{\psi\theta\xi}{m^2} \\ 1 & w & p \end{bmatrix} \begin{bmatrix} \frac{\partial c}{\partial \tau} \\ \frac{\partial l}{\partial \tau} \\ \frac{\partial m}{\partial \tau} \end{bmatrix} = \begin{bmatrix} -wU' \\ 0 \\ 0 \end{bmatrix}. \tag{4}$$

Applying the Cramer's rule, we can solve (4) as:

$$\frac{\partial l}{\partial \tau} = \frac{D_l}{D} > 0, \quad \frac{\partial c}{\partial \tau} = \frac{D_c}{D} < 0, \quad \frac{\partial m}{\partial \tau} = \frac{D_m}{D} < 0,$$

where

$$D \equiv \left[\frac{\psi(1-\theta)\xi}{l^2} - w^2(1-\tau)U'' - V''\right]\frac{\psi\theta\xi}{m^2} - p^2U''\left[\frac{\psi(1-\theta)\xi}{l^2} - V''\right] > 0,$$

$$D_l \equiv wU'\left(\frac{\psi\theta\xi}{m^2} - p^2U''\right) > 0,$$

$$D_c \equiv -w^2U'\frac{\psi\theta\xi}{m^2} < 0,$$

$$D_m \equiv pw^2U'U'' < 0,$$

where the strict inequalities above follow from the fact that $U' > 0$, $V' > 0$, $U'' < 0$, $V'' < 0$, and $w = A > 0$ as resultant from the firm's profit maximization problem.

Thus two crucial testable implications born out of the model are:

$$\frac{\partial l}{\partial \tau} > 0 \quad \text{and} \quad \frac{\partial m}{\partial \tau} < 0. \tag{5}$$

The result that a greater tax wedge implies more leisure time so less working time echoes the message of Prescott (2004). The message that a greater tax wedge leads to re-balancing health investment portfolio by using more leisure time activity and less medical expenditure for producing and maintaining health is totally new.

We now turn to the next section that empirically tests these two hypotheses.

4 Empirical Analysis

An important hypothesis derived from the illustrative model above is that tax wedge can negatively impact health care expenditures. Another important hypothesis is that changes in the tax wedge can lead to rebalancing of health investment portfolio. This section aims to test these two hypotheses empirically.

4.1 Measure of Health-Enhancing Leisure Time

In the simple theoretical model above, health-enhancing leisure time is taken as the residual of work time from total time endowment. This simplification is without loss of generality for the purpose of qualitatively illustrating the said testable implications while it helps make the illustration in a transparent way.

In actuality non-working time activity is not necessarily all health-enhancing. Thus for our empirical analysis in this section, and subsequent theoretical modeling and quantitative exercises, we want to tease out health-enhancing leisure time from the total leisure time. For this purpose we appeal to micro-level data from the Multinational Time Use Study (MTUS).

MTUS was originally developed by Jonathan Gershuny in the mid 1980s. Since then it has grown to offer harmonized episode and context information and to encompass over 60 datasets from 25 countries, including recent data from the American Time Use Survey (ATUS) and other national level time use projects.[12] It allows researchers to analyze time spent by different sorts of people in various sorts of work and leisure activities, over the last 55 years and across 30 countries.

Using MTUS data, we classify five categories of time use.[13] 1). The "clearly defined" (according to the literatures of biomedical science, public health, psychobiology, and biosociology) health-enhancing leisure time, such as time spent on sports, exercises, gardening, and go-out time. We label this category "leisure time 1." 2). The "not so sure" health-enhancing leisure time, such as time spent on watching TV and playing computer games. We label this category "leisure time 2." 3). Time spent on personal care, such as sleeping and eating time. 4). Working time, which is all the time spend on work. 5). Others, which include mostly time spent on home production (e.g., homework, shopping, cleaning time). Departing from data of potentially health-enhancing leisure time in the third column of Table 1, exploring micro-level MTUS data allows us to differentiate further that broadly defined leisure time into

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[12] Except Belgium and Finland, the other six European countries studied in Table 1 are covered in MTUS.

[13] See Appendix I for the details.

health-enhancing and not so health-enhancing leisure time. The fourth column in Table 1 shows the narrowly defined health-enhancing leisure time, i.e., “leisure time 1” for selected countries.

4.2 Tax Wedge and Health Expenditure

The illustrative model in Section 3 predicts a negative association of health expenditure with tax wedge. In our first empirical analysis we test this implication directly, using country-level health care expenditure and taxation data. One measure of health care cost that is comparable across countries is the ratio of health spending to GDP. Thus our first empirical test is on the hypothesis that health expenditure-GDP ratio is negatively associated with tax wedge.

Our tax-wedge data are constructed using the consumption and labor income tax data from McDaniel (2007) and its updates, same source as data in the fifth and sixth columns of Table 1. Our data on health expenditure-GDP ratio are adapted from World Health Organization (WHO).[14] Our data constructed this way cover all OECD countries for the period 2000-2016. Figure 1 plots the health expenditure-GDP ratio against the tax wedge. It is a clear negative relationship, just as the illustrative model predicts.

We then conduct empirical analysis by further controlling other factors that could potentially affect health expenditure-GDP ratio. To this end, we regress the health expenditure-GDP ratio on the tax wedge and a set of controls, including capital income tax (using data from McDaniel 2007 and its updates), as well as GDP per capita, old age dependency ratio, and life expectancy at age 65 (using data from World Bank National Accounts).[15] To control for institutional differences in health care system, we also include general government health expenditure-GDP ratio (using data from WHO) into the regressors. Table 2 provides summary statistics of all data. Table 3 reports the country frequency in our sample. As one can see, the data sample consists of an unbalanced panel.

We use two methods to tackle the panel structure. First, we run a static panel regression as shown in equation (6) for country i and time t. Second, following Arellano and Bond (1991), we run a GMM estimator dynamic panel regression as

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[14] OECD Health Data 2018 is also based on WHO data.

[15] We include GDP per capita to control for possible income effect on health care. Replacing GDP per capita with household income does not change our empirical results significantly.

shown in equation (7).[16]

$$
\begin{aligned}
M/Y_{i,t} &= \alpha_i + \beta tax\_wedge_{i,t} + \gamma X_{i,t} + \epsilon_{i,t}; &(6)\\
M/Y_{i,t} &= \rho M/Y_{i,t-1} + \beta tax\_wedge_{i,t} + \gamma X_{i,t} + \epsilon_{i,t}. &(7)
\end{aligned}
$$

Table 4 reports our regression results. As can be seen from the table, no matter which method is adopted, the results clearly show that health expenditure-GDP ratio is negatively associated with tax wedge. We view these results as a strong empirical support to the theoretical hypothesis.

4.3 Tax Wedge and Health-Enhancing Leisure Time

Our second empirical analysis digs deeper into the mechanism behind the conclusion from our first empirical test above - the conclusion is that a higher tax wedge leads to a lower health spending-GDP ratio. In particular, we here test the demonstrated portfolio re-balancing mechanism in health investment, that is, our theory's prediction that greater consumption or\and labor income tax rates, or, a greater tax wedge for short, lead to re-balancing of health investment portfolio by using more leisure and less medical goods and services for producing and maintaining health. As noted before, while labor taxation channel is relevant for working age people, consumption taxation channel matters for both workers and retirees.

To implement this second empirical test, we also use our health-enhancing leisure-time data constructed from MTUS (i.e., leisure time 1 and 2). In our baseline analysis, health-enhancing leisure time is measured in 'minutes', while in our robustness analysis it is measured as a 'percentage of total disposable time' (defined as total available time minus time spent on school, classes, dress/personal care, consume personal services, and sleep, following Duernecker and Herrendorf 2018). Table 5 reports the summary statistics of the corresponding data in MTUS. We drop from our sample people younger than 18 and people with current regular schooling time greater than 0. We also exclude the bottom and top 0.5% of the remaining sample ranked by leisure time to insulate the effect of potential outliers.

The mechanism at test is expected to produce a negative relation between medical expenditure and health-enhancing leisure time (due to variations in the tax wedge). To get a feel about whether this expectation is fulfilled at an intuitive level, Figure 2 plots health spending-GDP ratio against 'leisure time 1' and 'leisure time 2'. As is clear from the figure, when the clear-cut category of health-enhancing leisure time,

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[16] To deal with the potential endogeneity issue, we include the lagged health expenditure-GDP ratio in the regressors for the dynamic panel model.

that is, 'leisure time 1', is used, the expected negative relationship shows up very strongly, regardless of whether health-enhancing leisure time is measured in 'minutes' or as a 'percentage of total disposable time' (i.e., the left panel of the figure). Even when the more questionable category of health-enhancing leisure time is used, the expected negative relationship still shows up if health-enhancing leisure time is measured in 'minutes', even though not as significant as the case when the clean-cut category is used for health-enhancing leisure time.

To formally implement the empirical test, we use an instrumental variable (IV) approach to conduct two-step regressions shown in (8) and (9) as an attempt to deal with the endogeneity of time input in health production. In the first step we regress health-enhancing leisure time (leisure time 1 for the benchmark results and leisure time 1+2 for alternative results) on tax wedge and a set of controls for country i and time t. Our theory predicts the coefficient α in (8) to be positive. This is what the first-step regression obtains (see the first and second columns of Table 6). Then in the second step we regress health expenditure-GDP ratio on the fitted leisure time obtained from the first-step regression, along with a set of controls. And we expect, as our theory predicts, the coefficient θ in (9) to be negative.

$$\text{First-step:} \qquad leisure_{i,t} = \alpha tax\_wedge_{i,t} + \beta X_{i,t} + \epsilon_{i,t}; \tag{8}$$

$$\text{Second-step} \ : \quad M/Y_{i,t} = \theta \widehat{leisure}_{i,t} + \gamma X_{i,t} + \varepsilon_{i,t}. \tag{9}$$

As Table 6 shows, the estimate of θ is indeed negative, equal to -0.106, and it is statistically significant at the 1% level when the clear-cut measure of health-enhancing leisure time (i.e., 'leisure time 1') is used. By adding the "not so sure" category of health-enhancing leisure time to 'leisure time 1' (i.e., 'leisure time 1+2'), the estimated magnitude of θ decreases in absolute value, to -0.0208, but it remains statistically significant at the 1% level.

Taken together, our empirical investigations in this section lend support to the theoretical prediction of our illustrative model on the role of taxation in shaping health investment portfolio.

We turn now to our quantitative exercises using a life-cycle OLG macro-health model to quantify the extent to which the US-EU differences in consumption and labor income taxes (and in relative health care prices) can account for their differences in health care expenditures and time allocation for health production.

5 A Life Cycle Overlapping Generations Model

The simple theoretical model presented in Section 3 is for the purpose of illustrating qualitatively the working of the paper's main mechanism. For serious assessment of the quantitative significance of the highlighted mechanism, we want to take into account important aspects of health expenditures that are abstracted away from the simple model; for example, the fact that health care expenditures increase as an individual ages, and at a faster speed in late ages. We believe that any quantitative study on health expenditures should include age as an important dimension.

In this section, we present a large-scale life-cycle overlapping-generations model that is suitable for our quantitative analysis. The model follows the macro-health literature (e.g., Zhao 2014; Halliday et al. 2019) to feature endogenous health accumulation. Health directly enters into the utility function to provide consumption value. Better health also reduces sick time to allow more time for working or enjoying leisure. Finally, health positively affects survival probability.

5.1 Model Setting

5.1.1 Households

In each period there is a continuum of individuals with unit measure living in the economy. An individual starts working at age 1, retires at age j_R, and then lives through age J. From age 1, the expected lifetime utility of the individual is given by

$$\mathbb{E}\sum_{j=1}^{J}\beta^{j-1}\left[\prod_{k=1}^{j}\varphi_k(h_k)\right]u(c_j,v_j,h_j),$$

where β denotes the subjective discount factor, c is non-medical consumption, v is health-neutral leisure time, and h is health status. The term, $\varphi_j(h_j)$, represents the age-dependent conditional probability of surviving from age $j-1$ to j with the property $\varphi_1 = 1$ and $\varphi_{J+1} = 0$. The individual faces the following sequence of age dependent budget and time constraints: When working, i.e., for $j \in [1, j_R)$,

$$\begin{aligned} & (1+\tau_c)\left[c_j+(1-\phi_p)pm_j\right]+(1-\tau_n-\tau_{ss}-\tau_{med})\pi+a_{j+1}\leq \\ & (1-\tau_n-\tau_{ss}-\tau_{med})w\varepsilon_j\eta n_j+(1+r)a_j+T, \qquad (10) \\ 1 = {} & n_j+v_j+l_j+s(h_j) \qquad (11) \end{aligned}$$

In budget constraint equation (10), τ_c stands for consumption tax, τ_n is labor income tax, τ_{ss} is social security tax, and τ_{med} is Medicare tax. ε_j denotes age-specific (deterministic) efficiency at age j. η represents an idiosyncratic productivity shock an individual receives at every age. We assume that η follows a first-order autoregressive stochastic process. w denotes the wage rate and r denotes the rate of return on asset holdings a. Accordingly, $w\varepsilon_j\eta n_j$ is age-j labor income. T is a lump-sum transfer which comes partially from the accidental bequests left by the people who die in the period and partially comes from the tax revenue that government collects. The right hand side of equation (10) thus is her total disposable income at age j. On the left hand side, she needs to use the income to consume (c), spend on medical expenditures (pm), and save. Every working-age individual is enrolled in private health insurance. She pays the health insurance premium π, which is exempted from taxation and, in exchange, a fraction, ϕ_p, of her medical expenditures are paid by the insurance company. In other words, she only needs to pay $1-\phi_p$ percent of total medical expenditures out of her own pocket.

Time constraint equation (11) says that each period an individual is endowed with one unit of discretionary time. She spends her time in working (n), enjoying health-neutral leisure (v), invest in health production (l), and being sick (s). We assume that "sick time," s, is a decreasing function of health status so that $s'(h_j) < 0$.

After retirement, i.e., for $j \in [j_R, J]$, an individual faces the following sequence of age dependent budget and time constraints:

$$\begin{aligned} (1+\tau_c)\left[c_j + (1-\phi_m)pm_j\right] + a_{j+1} &= b + (1+r_j)a_j + T, && (12) \\ v_j + l_j + s(h_j) &= 1. && (13) \end{aligned}$$

Notice that b denotes the social security benefits. Following Imrohoroglu, Imrohoroglu, and Joines (1995), we model the Social Security as a pay-as-you-go system. b is calculated to be a fraction κ of some base income, which we take as the average lifetime labor income

$$b = \kappa \frac{\sum_{j=1}^{j_R-1} w\varepsilon_j\eta n_j}{j_R - 1}, \tag{14}$$

where κ is the replacement ratio. A retiree is also automatically enrolled in the Medicare system. To receive Medicare, she does not need to pay a premium. Yet, Medicare pays a fraction ϕ_m of her medical expenditures.

For asset holdings a_j, we assume that she holds zero asset both when first entering the labor force and when finally leaving the world. In addition, she faces a borrowing constraint over the lifespan,

$$a_1 = a_{J+1} = 0,\ a_j \geq 0,\ \text{for } j \in (1, J].$$

Another defining feature of the model is that health depreciation rate is age dependent $\{\delta_{h_j}\}_{j\in[1,J)}$. And health status follows the law of motion

$$h_{j+1} = (1-\delta_{h_j})h_j + g(m_j, l_j), \tag{15}$$

This configuration of age-specific health depreciation rate profile, together with proper calibration of the elasticity of substitution between consumption and health in the utility function, make the model consistent with the life cycle patterns of health expenditures, which can increase substantially with age and be concentrated in the last years of life (e.g., Jung and Tran 2010; Halliday et al. 2019). Finally, as shown in equation (15), new investment in health status is produced using both medical consumption and health-enhancing leisure time.

We summarize the individual's dynamic problem as a dynamic programming. For any age j, the state space at the beginning of age j is a vector (a_j, h_j, η). We let $V_j(a_j, h_j, \eta)$ denote the value function at age j given the state vector (a_j, h_j, η). The Bellman equation is then given by

$$V_j(a_j, h_j, \eta) = \max_{c_j, m_j, a_{j+1}, h_{j+1}, n_j, v_j, l_j} \left\{ u(c_j, v_j, h_j) + \beta \mathbb{E}_{\eta'|\eta}\left[\varphi_{j+1}(h_{j+1}) V_{j+1}(a_{j+1}, h_{j+1}, \eta')\right]\right\} \tag{16}$$

subject to

$$\begin{aligned}
(1+\tau_c)\left[c_j + (1-\phi_p)pm_j\right] + (1-\tau_n-\tau_{ss}-\tau_{med})\pi + a_{j+1} &\leq \\
(1-\tau_n-\tau_{ss}-\tau_{med})w\varepsilon_j\eta n_j + (1+r)a_j + T,\ \forall j &< j_R, \\
(1+\tau_c)\left[c_j + (1-\phi_m)pm_j\right] + a_{j+1} &= b + (1+r_j)a_j + T,\ \forall j \geq j_R, \\
n_j + v_j + l_j + s(h_j) &= 1,\ \forall j < j_R, \\
v_j + l_j + s(h_j) &= 1,\ \forall j \geq j_R, \\
h_{j+1} &= (1-\delta_{h_j})h_j + g(m_j, l_j), \\
a_{j+1} &\geq 0,\ \forall j,\ a_1 = 0,\ h_1 \text{ is given.}
\end{aligned}$$

5.1.2 Production

Next, we describe the production side of the economy. At date t, a representative firm combines labor and capital inputs to produce the final good, according to the constant-return-to-scale technology

$$Y_t = F(K_t, N_t) = K_t^{\alpha} N_t^{1-\alpha}.$$

The capital stock follows the law of motion

$$K_{t+1} = (1-\delta_k)K_t + I_t.$$

The firm maximizes profit

$$\Pi_t = F(K_t, N_t) - (r_t + \delta_k)K_t - w_t N_t.$$

Profit maximization yields the following optimality conditions

$$w_t = F_N(K_t, N_t),\ r = F_K(K_t, N_t) - \delta_k.$$

5.1.3 Government

The government plays three roles in the economy. First, it collects consumption tax and labor income tax and returns the total tax revenue to all living individuals in a lump-sum fashion. Second, it maintains the pay-as-you-go social security system by imposing social security tax (τ_{ss}). Finally, it also imposes Medicare tax (τ_{med}) to support a self-financing Medicare system.

5.2 Competitive Equilibrium

We are going to study the steady state of the model economy. For that purpose, we define the equilibrium of the model economy as follows.

Definition 1 *A stationary recursive equilibrium is a collection of individual value functions* $V_j(a_j, h_j, \eta)$*, individual policy rules* $C_j(a_j, h_j, \eta)$, $M_j(a_j, h_j, \eta)$, $A_j(a_j, h_j, \eta)$, $H_j(a_j, h_j, \eta)$, $N_j(a_j, h_j, \eta)$, $\nu_j(a_j, h_j, \eta)$, $L_j(a_j, h_j, \eta)$*, a measure of agent distribution* $\Phi_j(a_j, h_j, \eta)$ *for every age* j*, and a lump-sum transfer* T*, together with aggregate consumption* C*, health expenditure* M*, stock of physical capital* K*, labor input* N*, and wage and interest rates* w *and* r*, such that:*

1. *Given constant prices* $\{w, r\}$*, the policies* $\{\kappa, \tau_n, \tau_c, \tau_{ss}, \tau_{med}\}$*, the health insurances, and the lump-sum transfer* T*, individual value functions and policy rules solve an agent's dynamic programming problem as in (16).*

2. *The distribution of the measure of age-*j *agents* $\Phi_j(a_j, h_j, \eta)$ *follows the law of motion,*

$$\Phi_{j+1}(a', h', \eta') = \sum_{a:a'=A_j(a,h,\eta)} \sum_{h:h'=H_j(a,h,\eta)} \sum_{\eta} \Gamma(\eta, \eta')\varphi_{j+1}(H_j(a, h, \eta))\Phi_j(a, h, \eta),$$

where $\Gamma(\eta, \eta')$ *is the transition probabilities matrix.*

3. The share of age-j agents $\mu_j, \forall j$ *is determined by,*

$$\begin{aligned}
\Psi_j &= \sum_a \sum_h \sum_\eta \Phi_j(a,h,\eta), \\
\mu_j &= \frac{\Psi_j}{\sum_{i=1}^J \Psi_i}, \ \forall j,
\end{aligned}$$

where Ψ_j *is the measure of all age-j agents.*

4. Aggregate measures are consistent with aggregation across different age groups,

$$\begin{aligned}
C &= \sum_{j=1}^{J} \sum_a \sum_h \sum_\eta \mu_j \Phi_j(a,h,\eta) C_j(a_j,h_j,\eta), \\
M &= \sum_{j=1}^{J} \sum_a \sum_h \sum_\eta \mu_j \Phi_j(a,h,\eta) M_j(a_j,h_j,\eta), \\
K &= \sum_{j=1}^{J} \sum_a \sum_h \sum_\eta \mu_j \Phi_j(a,h,\eta) A_j(a_j,h_j,\eta), \\
H &= \sum_{j=1}^{J} \sum_a \sum_h \sum_\eta \mu_j \Phi_j(a,h,\eta) H_j(a_j,h_j,\eta), \\
N &= \sum_{j=1}^{j_R-1} \sum_a \sum_h \sum_\eta \mu_j \Phi_j(a,h,\eta) \varepsilon_j N_j(a,h,\eta), \\
\nu &= \sum_{j=1}^{j_R-1} \sum_a \sum_h \sum_\eta \mu_j \Phi_j(a,h,\eta) \varepsilon_j \nu_j(a,h,\eta), \\
L &= \sum_{j=1}^{j_R-1} \sum_a \sum_h \sum_\eta \mu_j \Phi_j(a,h,\eta) \varepsilon_j L_j(a,h,\eta).
\end{aligned}$$

5. Wage and interest rates are consistent with profit maximization,

$$w = F_N(K,N), \ r = F_K(K,N) - \delta_k.$$

6. The lump-sum transfer T *is determined by two parts, accidental bequests and tax rebates, so that ,*

$$T = AB + TR,$$

$$\begin{aligned} AB &= \sum_j \sum_a \sum_h \sum_\eta \mu_j \Phi_j(a,h,\eta)(1-\varphi_{j+1}(H_j(a,h,\eta)))A_j(a,h,\eta), \\ TR &= \tau_c(C+pM)+\tau_n wN. \end{aligned}$$

7. *Social Security system is pay-as-you-go,*

$$\tau_{ss} = \frac{b\sum_{j=j_R}^{J}\mu_j}{wN}.$$

8. *Medicare system is self-financing,*

$$\tau_{med} = \frac{\phi_m \sum_{j=j_R}^{J}\sum_a \sum_h \sum_\eta \mu_j \Phi_j(a,h,\eta)M_j(a,h,\eta)}{wN}.$$

9. *Private health insurance satisfies a zero profit condition,*

$$\pi = \frac{\phi_p \sum_{j=1}^{j_R-1}\sum_a \sum_h \sum_\eta \mu_j \Phi_j(a,h,\eta)M_j(a,h,\eta)}{\sum_{j=1}^{j_R-1}\mu_j}.$$

10. *Goods market clears,*

$$C + pM + K' - (1-\delta_k)K = F(K,N).$$

6 Calibration

For our quantitative analysis, we parameterize the OLG model described above and calibrate the parameterized model to match the relevant aspects of the US economy for the period 1990-2015.[17] Our calibration exercise is similar to that in Halliday et al. (2019) who calibrate a life-cycle model with endogenous health accumulation to study the life-cycle pattern of health expenditures.

6.1 Demographics

We assume that one model period corresponds to five years and an individual enters into the labor force at age 20 ($j = 1$), retires at age 65, and dies at age 90. This latter assumption implies $j_R = 10$ and $J = 16$.

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[17] Constrained by data availability, some moments are only available for a shorter period such as 2002 or 2003-2007. Horenstein and Santos (forthcoming) find that the cross-country gap in medical expenditure-GDP ratio between the US and European countries increased mostly for the period 1978-1990 and the gap has stabilized after 1990. This finding justifies our use of the period 1990-2015 for the US economy in calibrating a steady state of the model economy.

6.2 Preferences

Our period utility function takes the form,

$$u(c_j, v_j, h_j) = \frac{[\lambda(c_j^{\rho} v_j^{1-\rho})^{\psi} + (1-\lambda)h_j^{\psi}]^{\frac{1-\sigma}{\psi}}}{1-\sigma} + \underline{c}.$$

We assume that non-medical consumption and leisure are non-separable and we take a Cobb-Douglas specification as the benchmark. The parameter ρ determines the weight of non-medical consumption in the consumption-leisure bundle. Given the lack of consensus about the elasticity of substitution among non-medical consumption, leisure, and health, we allow for a flexible CES specification between the consumption-leisure bundle and health. The parameter λ thus measures the relative importance of the consumption-leisure bundle in the utility function. The elasticity of substitution between the consumption-leisure bundle and health is $\frac{1}{1-\psi}$. The consumption-leisure-health combination itself takes the form of CRRA utility function with the parameter σ determining the intertemporal elasticity of substitution. Finally, the inclusion of a constant term $\underline{c}$>0 is to guarantee that the period utility is positive so that people would prefer to live longer (e.g., Hall and Jones 2007).

Next, following Halliday et al. (2019), we assume that the survival probability is a logistic function that depends on health status,

$$\varphi_j(h_j) = \frac{1}{1 + \exp(\varpi_0 + \varpi_1 j + \varpi_2 j^2 + \varpi_3 h_j)}, \tag{17}$$

where we assume $\varpi_3 < 0$ so that the survival probability is an increasing function of an individual's health. Note that the survival probability is age-dependent, and that given suitable values for ϖ_1 and ϖ_2 it is decreasing with age at an increasing rate.

We calibrate the annual subjective discount factor to 0.956 to match the capital-output ratio of 2.5 in year 2002, so that $\beta = (0.956)^5$. We choose $\sigma = 2$ to obtain an intertemporal elasticity of substitution of 0.5, which is a value widely used in the literature. We calibrate the share of the consumption-leisure bundle in the utility function, λ, to 0.85 to match the average consumption-labor income ratio for working age adults, which is 78.5%. We calibrate the share of consumption ρ to 0.45 to match the fraction of working hours in discretionary time for workers, which is 0.31 from the Total Economy Database (TED).[18] We calibrate ψ, the parameter governing the elasticity of substitution between the consumption-leisure bundle and health, to -7.0, which implies an elasticity of $\frac{1}{1-\psi} = 0.125$. This value is chosen

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[18] The TED shows that average American workers work 1807 hours per week in 2002. We divide this number by 16×360 to convert it into a ratio to discretionary time, which is 0.31.

to match the average ratio of non-medical consumption to medical expenditure for working age in 2002, which is 13.5 (data are taken from Consumer Expenditure Survey (CEX) and MEPS).[19] Compared to the elasticity of substitution between consumption and leisure (equal to 1 given the Cobb-Douglas specification), health and the consumption-leisure bundle are complements. This implies that the marginal utility of consumption increases as the health stock improves, which is confirmed by several empirical studies (Viscusi and Evans 1990; Finkelstein, Luttmer, and Notowidigdo 2010). Finally, we calibrate $\underline{c}$ to match the ratio of the change in survival to the change in medical expenditures from ages 65-69 to 55-59, which is -0.06 in the MEPS data. The resulting $\underline{c}$ is 3.5. As Hall and Jones (2007) point out, $\underline{c}$ also determines the value of a statistical life (VSL). Our benchmark model generates an average VSL of 9.93 million dollars, which falls into the range of the estimates found in the empirical literature (e.g., Rohlfs, Sullivan, and Kniesner 2015).

For age-dependent survival probability, following Halliday *et al.* (2019), we calibrate the four parameters ϖ_0, ϖ_1, ϖ_2, and ϖ_3 to match four moment conditions involving survival probabilities in the data (US Life Table 2002): 1) Dependency ratio ($\frac{\text{number of people aged 65 and over}}{\text{number of people aged 20-64}}$), which is 39.7%. 2) Age-share weighted average death rate from age 20 to 100, which is 8.24%. 3) The ratio of survival probabilities for ages 65-69 to ages 20-24, which is 0.915. 4) The ratio of the change in survival probabilities from ages 65-69 to 75-79 to the change in survival probability from ages 55-59 to 65-69 ($\frac{\varphi_{12}-\varphi_{10}}{\varphi_{10}-\varphi_8}$ in the model), which is 2.27. The calibration obtains $\varpi_0 = -5.81; \varpi_1 = 0.285; \varpi_2 = 0.0082; \varpi_3 = -0.17$.

6.3 Health Production and Sick Time

We parameterize the age dependent health depreciation rate profile $\{\delta_{h_j}\}_{j\in[1,J)}$ using the following functional form,

$$\delta_{h_j} = \frac{\exp(d_0 + d_1 j + d_2 j^2)}{1 + \exp(d_0 + d_1 j + d_2 j^2)},$$

based on the study by Halliday *et al.* (2019).

For health production function, following Scholz and Seshadri (2010), we assume that it takes the form,

$$g(m_j, l_j) = B(m_j^{\theta} l_j^{1-\theta})^{\xi}, \tag{18}$$

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[19] Although using a different target, our calibration of ψ comes surprisingly close to what Scholz and Seshadri (2010) obtain, which is -7.2. Notice that we share the same period utility function.

where B measures the productivity of medical care, θ measures the relative importance of goods (medical consumption) input in health production, and ξ measures the degree of returns to scale in health production.

Following Grossman (1972), we assume that sick time is a decreasing function of health status which takes the following form,

$$s(h_j) = Qh_j^{-\gamma}, \tag{19}$$

where Q is a scaling factor and γ measures the sensitivity of sick time to health.

The three parameters d_0, d_1, and d_2 are calibrated to match three moment conditions of health status over the life cycle, and their resulting values are $d_0 = -3.7371$, $d_1 = 0.2502$, and $d_2 = 0.017$. The three moment conditions are: average health status from age 20 to 74, the ratio of health status for ages 20-29 to for ages 30-39, and the ratio of health status for ages 30-39 to for ages 40-49. The calibrated health depreciation rate increases over the life cycle.

The three parameters governing the health production function are calibrated to match three relevant moment conditions. We calibrate $B = 2.4$ to match the average medical expenditure-GDP ratio for the period 1990-2015, which is 14.2%. We calibrate $\theta = 0.15$ to match average health-enhancing leisure time ('leisure time 1' in Section 4) in ATUS for the period 1990-2012, which is 137 minutes per day. Finally, ξ is calibrated to be 0.93 to match the average medical expenditure-labor income ratio from age 20 to 64, which is 5.8% (data taken from MEPS and PSID) for the period 2003-2007.

For the two parameters that govern how health affects sick time, we calibrate Q and γ to match two moment conditions from the data documented in Lovell (2004): First, employed adults in the US on average miss 4.6 days of work per year due to illness or other health-related factors. This translates into 2.1% of total available working days. We calibrate $Q = 0.01$ to match this ratio. Second, the absence rate increases with age. For workers between ages 45 and 64, it is 5.7 days per year which is 1.5 days higher than the rate for younger workers between ages 18 and 44. Therefore the ratio of average sick time for ages 45-64 to for ages 18-44 is 1.36. We calibrate $\gamma = 7.0$ to match this ratio.

Finally, p is the relative price of health care (compared to non-medical consumption). We take $p = 1.20$ as documented in He, Huang, and Hung (2013), meaning that the price of health care is 20% higher than that of non-medical consumption in the US.

6.4 Social Security and Health Insurance

The Social Security replacement ratio κ is set to 40%, a common value used in the literature (e.g., Kotlikoff *et al.* 1999). Social Security tax τ_{ss} then is endogenously determined in the equilibrium. The MEPS data show that on average American retirees have about 80% of their medical expenditures paid by health insurance, of whom the majority have Medicare. For the working age population, employer-based health insurance (EHI) pays the majority of medical expenditures. The coverage rate of EHI is roughly 70-80%. Therefore, we set both coverage rates for private insurance and Medicare to 80%. Medicare tax rate τ_{med} is also endogenously determined in the equilibrium.

6.5 Taxes

We set consumption tax rate τ_c and labor income tax rate τ_n to be the average in the US data for the period 1990-2015 (data taken from McDaniel 2007 and its updates). We set $\tau_n = 10.6\%$ and $\tau_c = 7.6\%$ accordingly.

6.6 Labor Productivity

An individual's labor productivity depends on two parts: a deterministic age-dependent efficiency component and a stochastic idiosyncratic productivity shock. We take the age-efficiency profile $\{\varepsilon_j\}_{j=1}^{j_R-1}$ from Conesa, Kitao and Krueger (2009), who constructed it following Hansen (1993). For the idiosyncratic component η, we follow Heathcote *et al.* (2010) and Huggett (1996) and assume that the log of η follows a first-order autoregressive process with a persistence parameter $\rho_\eta = 0.96$ and the variance of the white noise $\sigma_\eta^2 = 0.018$. We then approximate this continuous process with a two-state, first-order discrete Markov process. The two realizations of shock are $\eta_1 = 0.67$ and $\eta_2 = 1.45$. And the corresponding 2×2 transition matrix is $\begin{bmatrix} 0.9978 & 0.0022 \\ 0.0022 & 0.9978 \end{bmatrix}$. The invariant distribution of the two states is $\begin{bmatrix} 0.5 & 0.5 \end{bmatrix}$.

6.7 Production

We set to 0.36 the capital income share α in the Cobb-Douglas production function. The annual capital depreciation rate is set to 0.10 so $\delta_k = 1 - (1 - 0.10)^5 = 0.41$.

Table 7 summarizes our model calibration results and Table 8 presents the matches for all of the moment conditions.

7 Quantitative Results

Given the calibrated parameter values, we solve the model numerically following the standard method (e.g., Aiyagari 1994, Imrohoroglu, Imrohoroglu, and Joines 1995).

Figure 3 reports the model's performance on several important aspects of life cycle behavior. First, the model is able to capture rising medical expenditures over the life cycle, especially the speed-up of medical expenditures after retirement (see panel A). Second, medical expenditures and health-enhancing leisure time jointly determine the evolution of health status over the life cycle in the model. As shown in panel B, the model is also able to capture declining health status over the life cycle. Third, in panel C, the model almost perfectly captures the dynamics of survival probabilities over the life cycle, thanks to the rich age-dependent structure of survival probabilities in the model as shown in equation (17). Fourth, the model is able to generate a hump-shape in working hours (see panel D). With this success, the model also generates a hump-shaped labor income profile, matching the data fairly well (see panel E). Finally, the model is able to capture the rising non-medical consumption for the first half of the life cycle, although it falls short on generating the significantly declining consumption after late 50s.

7.1 Quantifying the Effect of Taxation

To see the extent to which the observed difference in taxation may account for the observed differences in medical expenditure-GDP ratio and time allocation between the US and Europe, we first compute the steady-state equilibrium with all parameters taking their benchmark values calibrated to the US economy. Next we recompute the steady state by replacing the tax rates on labor income and consumption for the US with those for each of the eight European countries reported in the fifth and sixth columns of Table 1, while keeping all of the other parameters at their benchmark values reported in Table 7. The equilibrium values of the variables of interest in each of the eight cases can be compared with their values in the benchmark economy. These differences predicted by our model can then be contrasted with the differences observed in the data between each of the eight European countries and the US. These contrasts quantify the role of the differences in taxation between these European countries and the US in accounting for their observed differences in the underlying variables of interest. The results so obtained from our model simulations concerning the health care expenditure-GDP ratio (pm/y), time spent on paid work (n), time spent on narrowly defined health-enhancing leisure activity (l), and time spent on potentially health-enhancing leisure activity ($v + l$), are reported in Table 9. The table also presents the data counterparts constructed from MTUS as described in Section 2 and Section 4.1 (shown in Table 1), with which the simulation results are compared.

The first four columns of Table 9 record respectively the differences between each of the eight European countries (as well as the Euro Mean) and the US in these four measures of their data. These numbers are derived by subtracting the last row from each of the first nine rows in the first four columns of Table 1. Thus, the four numbers on the fourth row in the first four columns of Table 9 tell us that, the health expenditure-GDP ratio is 4.07% lower, the fraction of time spent on paid work is 5.8% lower, and the fraction of time spent on potentially health-enhancing leisure activity is 5% higher while time spent on narrowly defined health-enhancing leisure activity is 9.7 minutes longer per day, in Germany than in the US.

The middle four columns of Table 9 report respectively the variations of these four variables in our model when the labor income and consumption tax rates for the US are replaced by the tax rates in each of the eight European countries and by the average tax rates over these European countries. Thus, the four numbers on the fourth row in the middle four columns of Table 9 show our model's prediction that, the health expenditure-GDP ratio would be 2.03% lower, the fraction of time spent on paid work would be 1.7% lower, and the fraction of time spent on potentially health-enhancing leisure activity would be 1.0% higher while time spent on narrowly defined health-enhancing leisure activity would be 1.76 minutes longer per day, under the tax rates in Germany than under the tax rates in the US.

The contrast between the middle four columns and the first four columns of Table 9 confirms to our earlier conclusion based on analytical results. That is, our model's predicted US-Europe differences in the various variables of interest, which we recall are driven solely by their differences in taxation, are broadly consistent with their differences in these variables observed in the data. Generally speaking, the lower tax rates faced by Americans than by Europeans lead our model to predict a higher health care expenditure to GDP ratio, more time spent on paid work, and less time spent on health-enhancing leisure activity in the US than in Europe, which are exactly what we observe from the comparison of the US and European data.

The last four columns of Table 9 give us a more quantitative feel about the extent to which the differences in taxation between the US and Europe may help explain their observed differences in those variables of interest. The numbers in these last four columns of the table are obtained by dividing the numbers in the middle four columns, which we recall are generated from our model, by the corresponding numbers in the first four columns, which we recall are recorded from the data. As we scroll down from the first row to the eighth row in these columns to go over the results for each of the eight European countries, in comparison to the US, we can see that the cross-country differences in taxation provide a rather coherent account for the observed cross-country differences in the underlying variables of interest – sometimes to a great degree, and other times more modestly. As is illustrated by the last row in the last four columns of the table, on average, the US-EU differences in labor income and consumption tax rates account for 35.2% of their differences in health expenditure-GDP ratio,[20] 101.9% of their differences in time spent on paid work, 45.3% of their differences in time spent on potentially health-enhancing leisure activity, and 14.2% of their differences in time spent on narrowly defined health-enhancing leisure activity.[21]

7.2 Quantifying the Effect of Relative Health Care Price

A parallel exercise can be used to help isolate the effect of relative health care price. This is done in this section by recomputing the model's equilibrium while replacing the relative health care price in the US with that in each of the eight European countries reported in the eighth column of Table 1, but keeping all of the other parameters at their benchmark values reported in Table 7. The equilibrium values of the variables of interest in each of the eight cases are compared with their values in the benchmark economy. The resultant differences in health spending-GDP ratio, time spent on paid work, and time spent on potentially health-enhancing leisure activity and on narrowly defined health-enhancing leisure activity, which are reported in the middle four columns of Table 10, can then be contrasted with the differences in these variables observed in the data between each of the eight European countries and the US, which are presented in the first four columns of Table 10.

These numerical contrasts between our model's predictions and the data conform

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[20] It is worth noting that if we further assume that European countries have more generous public health insurance than the employer-based health insurance and Medicare in the US (e.g., if their co-pay rate is assumed to be even lower than 20%), the explanation power of the model on cross-country differences in the M/Y ratio would be lower than 35.2%.

[21] In the model cross-country difference in taxation explains the entire cross-country difference in working time. This result replicates the success of Prescott (2004). This perfectness of our model in matching the data on labor supply can be mainly due, as pointed out by Erosa, Fuster, and Kambourov (2012), to the assumption that tax revenues are distributed back to households in a lump-sum fashion. Additionally, in the US, most health insurance is provided through the employer for the working age population, which is tied to the job. While in Europe, a public single-payer system seems prevalent. The institutional difference in health insurances between Europe and the US can also potentially explain a fraction of cross-country differences in working hours, which the current model abstracts away. That said, our model's explanation power on labor supply might be on the upper side.

to our earlier discussion concerning the double-edged role of the US-Europe difference in relative health care price in shaping their differences in those variables of interest. Specifically, while cross-country difference in relative health care price does produce in our model cross-country difference in medical expenditure-GDP ratio in the same direction as observed from the data – implying that the effect of relative health care price difference on the cost per unit of medical consumption dominates its effect on the composition of health investment portfolio – it generates cross-country difference in time allocation in a direction that is exactly opposite to what is observed from most countries' data. Quantitatively, as the last row of Table 10 shows, the US-EU difference in relative health care price could account for 14.2% of their difference in medical expenditure-GDP ratio,[22] but it also predicts that paid work time would be 3.0% higher and time spent on potentially health-enhancing leisure activity would be 0.3% lower in Europe than in the US, while, in actuality, Europeans spend 4.4% less time on paid work and 4% more time on health-enhancing leisure activity when compared to Americans. Lastly, cross-country difference in relative health care price also predicts that Europeans on average would spend 0.7 minutes less per day in narrowly defined health-enhancing leisure activity than Americans, while the data show that Europeans actually spend 16.1 more minutes per day than Americans on narrowly defined health-enhancing leisure activity.

7.3 Joint Effects of Taxation and Relative Health Care Price

We assess in this section the joint effects of taxation and relative health care price. To do so, we recompute the model's equilibrium by replacing both the labor income and consumption tax rates and the relative health care price for the US with those for each of the eight European countries reported in the fifth to the eighth columns of Table 1, while keeping all of the other parameters at their benchmark values reported in Table 7. The equilibrium values of the variables of interest in each of the eight cases are compared with their values in the benchmark economy. The resultant differences in health spending-GDP ratio, time spent on paid work, and time spent on potentially health-enhancing leisure activity and on narrowly defined health-enhancing leisure activity, which are reported in the middle four columns of

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[22] It is worth noting that the construction of price index for health care often does not take into account changes in the quality of health care services. Lawver (2012) shows that after adjusting for health care quality changes, the price of medical goods and services in the US rose by only 26 percent over the period 1996-2007, less than half of the BLS's estimate of 54 percent. With higher TFP growth of the health care sector in the US than in Europe, taking into account health care quality changes across countries, the explanatory power of cross-country differences in the relative health care price can be moderated down from the level generated by our benchmark model.

Table 11, can then be contrasted with the differences in these variables observed from the data between each of the eight European countries and the US, which are presented in the first four columns of Table 11.

As is illustrated by these contrasts between our model's predictions and the data, the US-Europe differences in taxation and in relative health care price can jointly provide a fairly successful account of their differences in the underlying variables of interest (except perhaps for time spent on narrowly defined health-enhancing leisure activity). As can be seen from the last row in the last four columns of Table 11, on average, the US-EU differences in taxation and in relative health care price together account for 40.9% of their difference in health care expenditure-GDP ratio, 101.9% of their difference in time spent on paid work, and 46.2% of their difference in time spent on potentially health-enhancing leisure activity. Yet the US-EU differences in taxation and in relative health care price together account for only 5.2% of their difference in time spent on narrowly defined health-enhancing leisure activity. The power of the model is weakened by the inclusion of the relative health care price channel when it come to explaining the cross-country difference in time spent on narrowly defined health-enhancing leisure activity. This shall have been anticipated from our analysis in Section 7.2, and as discussed in the introduction, since, as is shown there, the US-Europe difference in relative health care price has an implication for time allocation that is in a direction opposite to the data.[23]

8 Sensitivity Analysis

In this section, we conduct sensitivity analyses to investigate how robust our quantitative results are to alternative specifications of important features of our model. Since health production function and private health insurance are two fundamental building blocks of the model, we focus on examining the robustness of our quantitative results to an alternative (and more general) form of health production function and alternative level of private health insurance. To demonstrate the importance of time input in health production, we also conduct a counterfactual exercise by abstracting away the health-enhancing leisure time from health production. To help conserve space, we confine our presentation in this section to sensitivity checks on the robustness of quantitative significance of the taxation channel, while any cross-country difference in relative health care price is muted. In each of the sensitivity and

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[23] It is worth noting that if changes in the quality of health care services are taken into account, actual US-EU difference in (quality-adjusted) health care price can be smaller than what is assumed in our benchmark model, and the model's performance in accounting for the US-EU difference in time allocation can be improved as a result.

counterfactual analyses proper calibration is conducted to ensure internal consistency across all model specifications and with the data.

8.1 Health Production Function

We consider a more general form of health production function,

$$g(m_j, l_j) = B\left[\theta m_j^{\frac{\omega-1}{\omega}} + (1-\theta) l_j^{\frac{\omega-1}{\omega}}\right]^{\frac{\omega\xi}{\omega-1}}, \tag{20}$$

where ω measures the elasticity of substitution between medical consumption and health-enhancing leisure time in health production, which is set to 1 in the baseline model. Clearly, the special case of (20) with $\omega = 1$ corresponds to the health production function (18) in the baseline model. We examine two alternative values of ω, 1.1 and 0.9, both of which are the range of empirical estimates by He, Huang, and Hung (2013).

Tables 12 and 13 report our quantitative results for the cases with $\omega = 1.1$ and $\omega = 0.9$, respectively. Recall that the key mechanism in our model – rebalancing of health investment portfolio due to variations in the tax codes hinges on the substitution between the goods and time inputs in health production. Thus it is natural to see that the explanation power of the model on US-EU difference in medical expenditure-GDP ratio is bigger (36.4% of data) with a higher elasticity of substitution between the two inputs ($\omega = 1.1$), but smaller (18% of data) with a lower elasticity of substitution ($\omega = 0.9$), compared with the benchmark case. In either case, the model accounts for a significant fraction of the US-EU difference in health expenditure attributive to their difference in the tax wedge.

8.2 Health Insurance

We here check the robustness of our quantitative results with respect to health insurance coverage. In the benchmark case, the coverage rate of employer-based health insurance (EHI) for workers is set equal to 0.8. If we were to set the coverage rate to a higher level, the power of our model in explaining the US-EU difference in medical expenditure-GDP ratio would be higher. To see how much worse our model's performance can go when this feature of the model is changed, we consider a lower level of coverage rate. Since a coverage rate of 0.6 can be arguably viewed as a lower bound for the actual coverage rate in the real world, we consider this level of coverage rate for a robustness check. Table 14 reports the results under the EHI coverage rate $\phi_p = 0.6$. As can be seen from the table, even with this 'lower-bound' coverage rate of EHI, the US-Europe difference in taxation is still able to explain 17% of the US-EU difference in medical expenditure-GDP ratio.

8.3 Perils of Abstracting Leisure from Health Production

The fact that not only medical care but leisure is important in maintaining health, which is incorporated in the baseline model in a way consistent with empirical evidence, is a key feature of the model for its success in explaining cross-country differences in medical expenditures. The theoretical illustration in Section 3 and empirical analysis in Section 4 both show, and subsequent numerical simulations of the large-scale life-cycle OLG model also confirm, that a key mechanism by which variation in taxation can affect medical expenditure-GDP ratio is through the impact of taxation on the composition of health investment portfolio and time allocation. If we abstract the time input away from health production, this mechanism would be weakened.

A counterfactual experiment helps put this into a more quantitative perspective. The mis-specified model as described above is configured by setting the share of time input in health production to zero, that is, by setting $\theta = 1$, accompanied with proper re-calibration to ensure internal consistency with the benchmark model and the data. The mis-specified model configured this way is then used to re-conduct the exercise described in Section 7.1. In this mis-specified model, the US-EU difference in the tax wedge would account for only 20.8% of their difference in medical expenditure-GDP ratio, as opposed to 35.2% in the benchmark model. This is to say that abstracting the time input away from health production by itself would lead to more than 40% decline in the explanatory power of the model.[24]

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[24] The more than 40% reduction in the explanatory power of the mis-specified model from that of the benchmark model is due to the loss of the portfolio re-balancing channel in health investment. The retained 20.8% explanatory power comes from two remaining effects of taxation that are present even in the mis-specified model. First, the health-neutral leisure – work time choice, inasmuch as being affected by the tax wedge, remains relevant for the working age people, which in turn affects their demand for medical goods and services. Second, and more importantly, the direct effect of consumption taxes on the demand for medical consumption continues to be relevant for both workers and retirees. Through the working of these two remaining channels, the remaining 20.8% explanatory power of the mis-specified model comes from the fact that both labor income and consumption tax rates are lower in the US than in Europe. As a result, both workers and retirees in Europe tend to consume less medical goods and services than their American counterparts, just as is observed from the data.

9 Concluding Remarks

We have documented two sets of empirical observations over the past many years. First, the US has spent a larger fraction of its GDP on health care and devoted more time to paid work and less time to health-enhancing leisure time activities, when compared to most comparably rich European countries. Second, labor income and consumption tax rates are considerably lower, while relative health care price is generally higher, in the US than in these Eurozone countries. We have shown that these two sets of facts may be related to each other, and a key to such link may have to do with another empirically relevant fact, which is also documented in this paper, that is, both leisure and medical care are important in maintaining health.

This fact that leisure and medical care are both important in maintaining health can be pertinent to other issues of interest. For instance, He *et al.* (2015) find that this portfolio view of health investment is important for understanding the joint cyclical behaviors of medical expenditure and health capital in modern industrialized economies. In light of these findings, further investigation of a broad set of macro-health issues for which this empirically motivated feature of health investment portfolio may be relevant should be elevated to the top of our research agenda.

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10 Appendix I: Categorizing Health-enhancing Leisure Time in MTUS

In this appendix, we provide details of the five categories of time use that we defined in the text. Notice that the original MTUS has two classification systems with 41 and 69 activities. We choose the system of 69 activities as our base. We divide these 69 activities into five groups as defined in the text. Tables 16–19 provide details of each category.

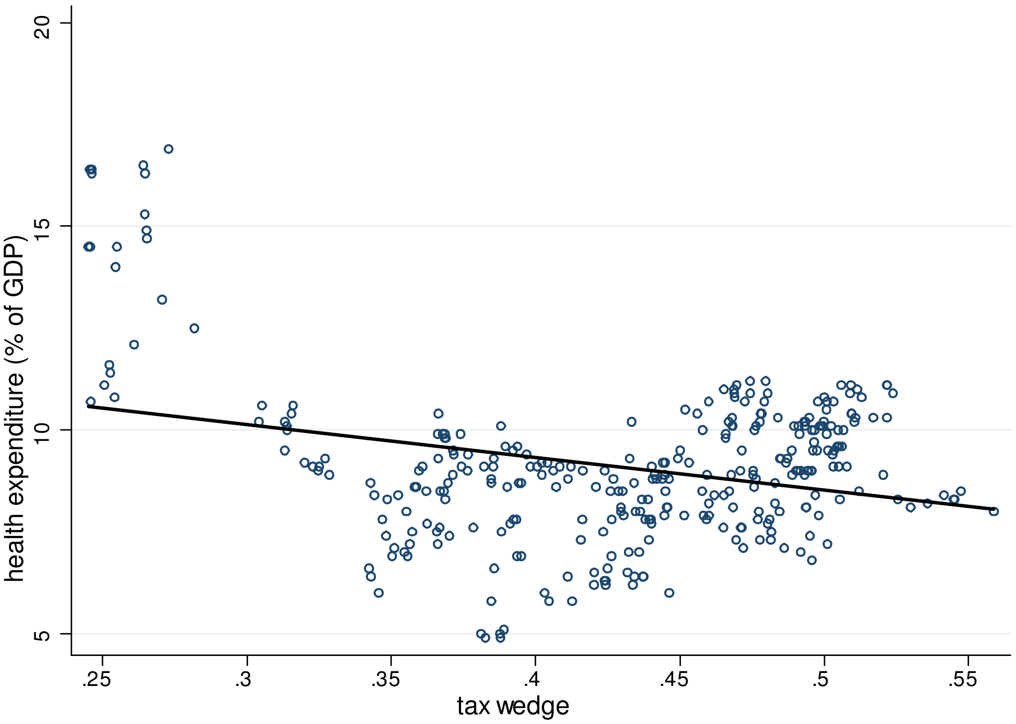

Figure 1: Health Expenditures and Tax Wedge: Cross-country Evidence

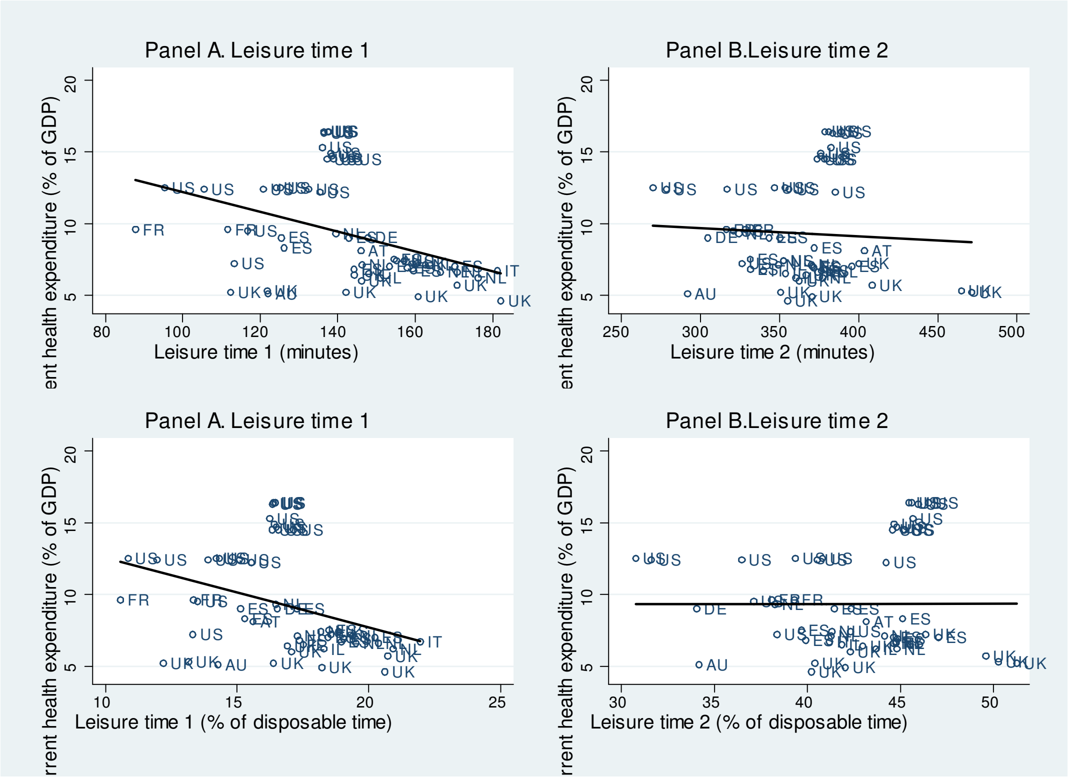

Figure 2: Health Expenditures and Health-enhancing Leisure Time: Cross-country Evidence

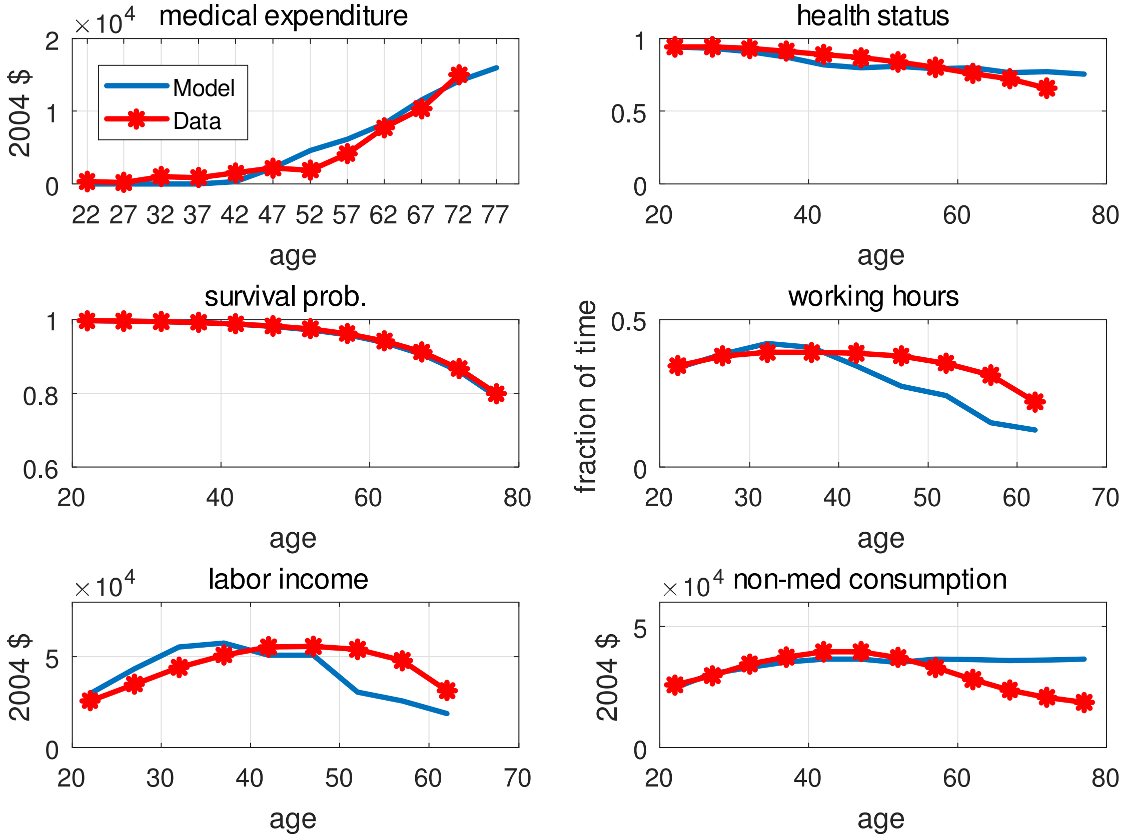

Figure 3: Life-cycle Profiles: Model vs. Data

Table 1: US and European Data: Long Run Averages

Country	$\frac{pm}{y}^{1}$(%)	n^2(%)	l^3(%)	$l_e{}^4$	$\boldsymbol{\tau}_n{}^5$(%)	$\boldsymbol{\tau}_c{}^6$(%)	τ^{f7}(%)	p^8
Belgium	8.8	27.3	71	n.a.	14.5	17.8	27.4	1.02
Finland	8.0	29.7	68	n.a.	15.8	21.9	30.9	1.14
France	9.9	26.9	68	108.81	9.3	23.4	26.5	1.11
Germany	10.1	25.2	69	146.48	9.9	15.1	21.7	0.94
Italy	8.0	31.5	67	181.13	12.7	19.2	26.8	1.24
Netherlands	8.7	25.1	68	159.72	9.2	17.8	22.9	0.94
Spain	7.7	30.0	67	147.99	8.2	14.9	20.1	0.92
UK	7.2	29.3	66	148.32	12.7	15.6	24.5	1.05
Euro Mean	8.5	28.1	68	152.89	11.2	18.2	24.9	1.04
US	14.2	31.0	64	136.78	10.6	7.6	16.9	1.20

Source: OECD Health Data, WHO, TED, MTUS.

[1] Health expenditure to GDP ratio-OECD Health Data 2018 and WHO.

[2] Fraction of time spent on paid work-TED.

[3] Fraction of time spent on potentially health-enhancing leisure activity-OECD (2011).

[4] Narrowly defined health-enhancing leisure time-MTUS (unit: minutes).

[5] Labor income tax rate-McDaniel (2007) and its updates.

[6] Consumption income tax rate-McDaniel (2007) and its updates.

[7] Tax wedge-Authors' calculation.

[8] Relative price of health care-He, Huang, and Hung (2013).

Table 2: Summary Statistics

Variable	**N**	**mean**	**p50**	**sd**	**min**	**max**
health expenditure GDP ratio (M/Y, %)	320	9.120	9	1.970	4.900	16.90
income tax (tau inc)	320	0.120	0.110	0.0600	0.0300	0.350
social security tax (tau ss)	320	0.190	0.220	0.0800	0.0200	0.310
total income tax (ltax)	320	0.310	0.310	0.0600	0.190	0.430
consumption tax (tauc)	320	0.210	0.200	0.0900	0.0400	0.550
tax wedge	320	0.430	0.440	0.0700	0.250	0.560
capital tax (tauk)	320	0.220	0.210	0.0700	0.100	0.440
gdp per capita	320	11.09	10.43	1.600	9.150	15.56
old age dependency ratio (old, %)	320	24.63	24.85	3.760	16.27	34.99
government health expenditure GDP ratio (gov_health, %)	320	6.670	6.780	1.540	0	9.420
life expectancy at age 65 (lifeexp65)	320	17.04	17.40	1.540	12.80	20.10

Table 3: The Frequency of Countries in the Empirical Analysis

Country	**Frequency**	**Percentage (%)**	**Cum. Percentage (%)**
Austria	12	3.75	3.75
Belgium	16	5	8.75
Canada	16	5	13.75
Czech Republic	13	4.06	17.81
Denmark	16	5	22.81
Estonia	13	4.06	26.88
Finland	16	5	31.88
France	16	5	36.88
Germany	16	5	41.88
Greece	8	2.5	44.38
Hungary	13	4.06	48.44
Iceland	12	3.75	52.19
Ireland	2	0.63	52.81
Italy	16	5	57.81
Netherlands	13	4.06	61.88
Norway	13	4.06	65.94
Poland	3	0.94	66.88
Portugal	16	5	71.88
Slovak Republic	11	3.44	75.31
Slovenia	13	4.06	79.38
Spain	13	4.06	83.44
Sweden	15	4.69	88.13
Switzerland	6	1.88	90
United Kingdom	16	5	95
United States	16	5	100
Total numbers	320		

Table 4: Panel Regressions of Tax Wedge and Health Expenditures

	Dependent Variable: health expenditure GDP ratio (%)			
	Static Panel Model		**Dynamic Panel Model**	
	(1)	(2)	(3)	(4)
M/Y_{-1}			0.632***	0.601***
			(0.082)	(0.098)
tax wedge	-11.553**	-12.011**	-10.288**	-8.148**
	(5.637)	(4.849)	(4.557)	(3.548)
tauk	-3.129	-2.945*	-3.674**	-3.585**
	(2.225)	(1.719)	(1.644)	(1.650)
gdppercapita		-0.589		-0.988
		(0.932)		(0.610)
old dependency		0.059		-0.020
		(0.081)		(0.055)
gov_health		0.175*		0.155*
		(0.103)		(0.088)
lifeexp65		0.206		-0.143
		(0.235)		(0.137)
country fixed effects	Y	Y	Y	Y
year fixed effects	Y	Y	Y	Y
Observations	320	320	270	270
R-squared	0.677	0.728		
Number of country	25	25	24	24

Note: Standard errors (in parentheses) are clustered at the country level, statistical significance at the 1%, 5%, and 10% levels are indicated by ***, **, and * respectively.

Table 5: Summary Statistics of MTUS

variable	**N**	**mean**	**p50**	**sd**	**min**	**max**
health expenditure-GDP ratio (%)	33	11.10	12.20	3.530	5.700	16.40
leisure time 1	33	135.0	137.4	17.90	87.84	170.7
leisure time 2	33	220.6	223.5	23.7	172.9	251.4
total disposable time	33	847.4	839.8	17.66	823.9	881.5

Table 6: Leisure and Health Expenditures: IV Estimation

	1st step: Dep. var.: leisure		**2nd step:**	**Dep. var.: M/Y**
	(1)	(2)	(3)	(4)
	leisure_time1	leisure_time 1+2		
leisure_time1			-0.106***	
			(0.0318)	
leisure_time2				-0.0208*
				(0.0112)
tax	86.14	316.3		
	(83.87)	(214.1)		
tauk	248.2***	600.9***		
	(77.89)	(205.3)		
regional fixed effects	Y	Y	Y	Y
year fixed effects	Y	Y	Y	Y
Observations	33	33	33	33
R-squared	0.889	0.918	0.754	0.957

Note: Robust standard errors are in parentheses, statistical significance at the 1%, 5%, and 10% levels are indicated by ***, **, and * respectively.

Table 7: Parameters of the Model

Parameter	**Description**	**Value**	**Source**
	Demographics		
J	maximum life span	16	age 95-99
j_R	mandatory retirement age	10	age 65-69
ϖ_0	survival prob.	-5.81	calibrated
ϖ_1	survival prob.	0.285	calibrated
ϖ_2	survival prob.	0.0082	calibrated
ϖ_3	survival prob.	-0.017	calibrated
	Preferences		
β	subjective discount rate	$(0.956)^5$	calibrated
σ	Intertem. ela. sub. coefficient	2	common value
ψ	elasticity b/w cons. and health	-7.0	calibrated
ρ	share of c in c-leisure combination	0.45	calibrated
λ	share of cons-leisure com. in utility	0.85	calibrated
$\underline{c}$	constant term in utility	3.5	calibrated
	Health Accumulation		
d_0	dep. rate of health	-3.7371	calibrated
d_1	dep. rate of health	0.2502	calibrated
d_2	dep. rate of health	0.017	calibrated
B	productivity of health technology	2.4	calibrated
θ	goods investment share in h tech	0.15	calibrated
ξ	return to scale for health investment	0.93	calibrated
p	relative price of health care	1.20	He et al. (2013)
	Sick Time		
Q	scale factor of sick time	0.01	calibrated
γ	elasticity of sick time to health	7.0	calibrated
	Labor Productivity		
$\{\varepsilon_j\}_{j=1}^{j_R-1}$	age-efficiency profile	see text	Conesa et al. (2009)
ρ_η	persistence of productivity shock	0.96	Heathcote et al. (2010)
σ_η	variance of productivity shock	0.018	Heathcote et al. (2010)
	Health Insurance		
ϕ_p	coverage rate, private insurance	0.8	MEPS data
ϕ_m	coverage rate, Medicare	0.8	MEPS data
	Social Security		
κ	Social Security replacement ratio	40%	Kotlikoff et al. (1999)
	Taxes		
τ_n	labor income tax	10.6%	McDaniel (2007)
τ_c	consumption tax	7.6%	McDaniel (2007)
	Production		
α	capital income share	0.36	US data
δ_k	capital depreciation rate	0.41	US data

Table 8: Target Moments: Data vs. Model

Target (Data source)	**Data**	**Model**
Capital-output ratio (NIPA)	2.5	2.6
Non-med. consumption-labor income ratio (CEX and PSID)	78.5%	83.0%
Non-med. consumption / Med. expenditure in working age (CEX)	13.5	14.7
Fraction of average working hours (TED)	0.31	0.30
Average health health-enhancing leisure-time (minutes, ATUS)	137	110
Med. expenditure-output ratio (OECD Health)	14.2%	15.0%
Med. expenditure-labor income ratio (MEPS and PSID)	5.8%	5.64%
Fraction of average sick time (ages 20-64) (Lovell 2004)	2.1%	3.5%
Sick time (ages 45-64) / Sick time (ages 20-44) (Lovell 2004)	1.36	2.2
Average health status (ages 20-74) (PSID)	0.845	0.84
Health (ages 20-29)/health (ages 30-39) (PSID)	1.02	1.05
Health (ages 30-39)/health (ages 40-49) (PSID)	1.05	1.10
Dependency ratio (US Life Table)	39.7%	39.1%
Average death rate (ages 20-100) (US Life Table)	8.24%	8.3%
Sur. prob. (ages 65-69)/sur. prob. (ages 20-24) (Life Table)	0.915	0.91
$\triangle$sur (65-69 to 75-79)/$\triangle$sur (55-59 to 65-69) (Life Table)	2.27	2.19
$\triangle$sur (55-59 to 65-69)/$\triangle$med. exp. (55-59 to 65-69) (MEPS and Life Table)	-0.06	-0.09

Table 9: EU-US Differences in Health Spending-GDP Ratio and Time Allocation: Data vs. Model, Taxation Channel Only

Country	**Data (%)**				**Model (%)**				**Explanation power (%)**			
	$\Delta\left(\frac{m}{y}\right)$	Δn	Δl	$\Delta l_e{}^*$	$\Delta\left(\frac{m}{y}\right)$	Δn	Δl	$\Delta l_e{}^*$	$\Delta\left(\frac{m}{y}\right)$	Δn	Δl	Δl_e
Belgium	5.42	3.7	-7.0	n.a.	1.39	2.0	-1.9	n.a.	25.7	52.8	26.5	n.a.
Finland	6.14	1.3	-4.0	n.a.	1.79	4.9	-3.1	n.a.	29.2	376.5	77.6	n.a.
France	4.27	4.1	-4.0	28.0	2.68	3.3	-2.3	-3.13	62.7	79.5	56.3	-11.2
Germany	4.07	5.8	-5.0	-9.70	2.03	1.7	-1.0	-1.76	49.7	28.5	19.5	18.1
Italy	6.20	-0.5	-3.0	-44.35	1.73	3.5	-2.4	-1.71	27.8	-694.8	79.4	3.9
Netherlands	5.49	5.9	-4.0	-22.94	1.56	0.6	-1.0	0.59	28.4	10.3	24.0	-2.6
Spain	6.5	1.0	-3.0	-11.21	1.38	1.4	-0.9	-1.14	21.2	138.4	31.4	10.2
UK	7.03	1.7	-2.0	-11.53	1.41	2.1	-1.1	-1.38	20.0	120.9	52.7	12.0
Euro Mean	5.64	2.9	-4.0	-16.11	1.99	3.0	-1.8	-2.29	35.2	101.9	45.3	14.2
US												

[*] Health-enhancing leisure time. Unit: minutes.

Table 10: EU-US Differences in Health Spending-GDP Ratio and Time Allocation: Data vs. Model, Price Channel Only

Country	**Data (%)**				**Model (%)**				**Explanation power (%)**			
	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	$\Delta l_e{}^*$	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	$\Delta l_e{}^*$	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	Δl_e
Belgium	5.42	3.7	-7.0	n.a.	0.65	-1.1	0.2	n.a.	11.9	-30.4	-3.2	n.a.
Finland	6.14	1.3	-4.0	n.a.	1.51	0.1	0.2	n.a.	24.6	9.9	-6.2	n.a.
France	4.27	4.1	-4.0	28.0	1.32	0.6	0.2	0.1	30.8	14.8	-4.4	0.2
Germany	4.07	5.8	-5.0	-9.70	1.88	0.1	0.2	1.6	46.2	1.7	-3.2	-16.1
Italy	6.20	-0.5	-3.0	-44.35	0.32	-0.1	0.1	-3.1	5.2	25.4	-2.9	6.9
Netherlands	5.49	5.9	-4.0	-22.94	0.77	-1.3	0.4	4.0	14.0	-22.0	-10.2	-17.4
Spain	6.5	1.0	-3.0	-11.21	1.16	-0.7	0.5	1.8	17.8	-68.7	-17.2	-16.2
UK	7.03	1.7	-2.0	-11.53	0.93	-0.1	0.4	0.4	13.2	-7.0	-22.4	-3.5
Euro Mean	5.64	2.9	-4.0	-16.11	0.80	-0.1	0.1	0.7	14.2	-3.0	-1.7	-4.2
US												

[*] Health-enhancing leisure time. Unit: minutes.

Table 11: EU-US Differences in Health Spending-GDP Ratio and Time Allocation: Data vs. Model, Taxation and Price Channels Jointly

Country	**Data** (%)				**Model** (%)				**Explanation power** (%)			
	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	$\Delta l_e{}^*$	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	$\Delta l_e{}^*$	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	Δl_e
Belgium	5.42	3.7	-7.0	n.a.	1.58	2.1	-2.0	n.a.	29.0	56.4	28.5	n.a.
Finland	6.14	1.3	-4.0	n.a.	1.58	4.9	-3.2	n.a.	25.6	376.5	79.1	n.a.
France	4.27	4.1	-4.0	28.0	2.62	3.6	-2.4	-1.68	61.2	87.9	60.5	-6.0
Germany	4.07	5.8	-5.0	-9.70	2.66	2.1	-1.0	0.64	65.4	35.9	20.3	-6.6
Italy	6.20	-0.5	-3.0	-44.35	1.74	3.6	-2.7	-3.67	28.1	-728.1	88.6	8.3
Netherlands	5.49	5.9	-4.0	-22.94	2.12	0.3	-0.7	3.27	38.6	5.2	18.4	-14.3
Spain	6.5	1.0	-3.0	-11.21	1.69	0.7	-0.5	1.87	26.0	65.8	15.9	-16.7
UK	7.03	1.7	-2.0	-11.53	1.37	2.2	-1.3	-0.67	19.5	130.9	66.3	5.8
Euro Mean	5.64	2.9	-4.0	-16.11	2.31	3.0	-1.8	-0.84	40.9	101.9	46.2	5.2
US												

[*] Health-enhancing leisure time. Unit: minutes.

Table 12: EU-US Differences in Health Spending-GDP Ratio and Time Allocation: Data vs. Model with Elasticity of Substitution = 1.1

Country	**Data (%)**				**Model (%)**				**Explanation power (%)**			
	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	$\Delta {l_e}^*$	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	$\Delta {l_e}^*$	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	Δl_e
Belgium	5.42	3.7	-7.0	n.a.	1.36	0.033	-2.5	n.a.	25.1	89.0	35.9	n.a.
Finland	6.14	1.3	-4.0	n.a.	1.77	0.053	-3.3	n.a.	28.9	406.6	83.3	n.a.
France	4.27	4.1	-4.0	28.0	2.08	0.032	-2.0	0.41	48.6	78.3	49.0	1.5
Germany	4.07	5.8	-5.0	-9.70	1.51	0.020	-1.2	-0.17	37.1	35.1	24.0	1.7
Italy	6.20	-0.5	-3.0	-44.35	1.33	0.038	-2.7	-0.15	21.4	-762.8	88.4	0.3
Netherlands	5.49	5.9	-4.0	-22.94	1.34	0.012	-1.1	-1.14	24.5	20.6	26.9	5.0
Spain	6.5	1.0	-3.0	-11.21	1.05	0.011	-0.8	0.22	16.1	112.7	26.6	-1.9
UK	7.03	1.7	-2.0	-11.53	1.27	0.029	-1.8	-0.38	18.1	168.4	91.8	3.3
Euro Mean	5.64	2.9	-4.0	-16.11	2.05	0.033	-2.0	-0.62	36.4	113.5	50.4	3.9
US												

[*] Health-enhancing leisure time. Unit: minutes.

Table 13: EU-US Differences in Health Spending-GDP Ratio and Time Allocation: Data vs. Model with Elasticity of Substitution = 0.9

Country	**Data (%)**				**Model (%)**				**Explanation power (%)**			
	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	$\Delta l_e{}^*$	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	$\Delta l_e{}^*$	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	Δl_e
Belgium	5.42	3.7	-7.0	n.a.	0.64	3.5	-2.3	n.a.	11.9	94.7	32.7	n.a.
Finland	6.14	1.3	-4.0	n.a.	1.15	5.0	-3.1	n.a.	18.7	386.0	77.0	n.a.
France	4.27	4.1	-4.0	28.0	1.73	3.9	-2.6	0.77	40.6	93.9	65.7	2.7
Germany	4.07	5.8	-5.0	-9.70	0.59	2.1	-1.4	1.34	14.5	35.8	27.5	-13.8
Italy	6.20	-0.5	-3.0	-44.35	1.15	3.7	-2.5	0.85	18.6	-744.0	84.4	-1.9
Netherlands	5.49	5.9	-4.0	-22.94	0.78	1.5	-1.1	0.42	14.1	25.6	26.9	-1.8
Spain	6.5	1.0	-3.0	-11.21	0.66	1.2	-0.7	1.19	10.2	116.4	22.5	-10.6
UK	7.03	1.7	-2.0	-11.53	1.02	3.2	-2.1	0.89	14.5	185.7	103.4	-7.7
Euro Mean	5.64	2.9	-4.0	-16.11	1.01	3.4	-2.3	0.76	17.9	117.8	58.2	-4.7
US												

[*] Health-enhancing leisure time. Unit: minutes.

Table 14: EU-US Differences in Health Spending-GDP Ratio and Time Allocation: Data vs.Model with EHI=0.6

Country	**Data (%)**				**Model (%)**				**Explanation power (%)**			
	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	$\Delta l_e{}^*$	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	$\Delta l_e{}^*$	$\Delta\left(\frac{pm}{y}\right)$	Δn	Δl	Δl_e
Belgium	5.42	3.7	-7.0	n.a.	0.30	0.026	-2.5	n.a.	5.6	71.5	36.1	n.a.
Finland	6.14	1.3	-4.0	n.a.	1.28	0.055	-3.6	n.a.	20.8	426.3	88.9	n.a.
France	4.27	4.1	-4.0	28.0	1.59	0.039	-2.5	-0.76	37.3	94.2	63.5	-2.7
Germany	4.07	5.8	-5.0	-9.70	0.92	0.021	-1.3	-0.82	22.6	36.0	26.1	8.5
Italy	6.20	-0.5	-3.0	-44.35	1.02	0.037	-2.4	-0.26	16.5	-745.3	80.7	0.6
Netherlands	5.49	5.9	-4.0	-22.94	0.76	0.008	-1.1	2.13	13.9	13.2	27.3	-9.3
Spain	6.5	1.0	-3.0	-11.21	0.52	0.013	-0.9	-0.01	8.0	134.5	29.9	0.1
UK	7.03	1.7	-2.0	-11.53	0.50	0.034	-2.3	-0.97	7.1	201.3	113.8	8.4
Euro Mean	5.64	2.9	-4.0	-16.11	0.96	0.036	-1.8	-1.01	17.0	124.2	44.9	6.3
US												

[*] Health-enhancing leisure time. Unit: minutes.

Table 15: EU-US Differences in Health Spending-GDP Ratio and Time Allocation: Data vs.Model without Health-enhancing Leisure Time

Country	**Data** (%)		**Model** (%)		**Explanation power** (%)	
	$\Delta\left(\frac{pm}{y}\right)$	Δn	$\Delta\left(\frac{pm}{y}\right)$	Δn	$\Delta\left(\frac{pm}{y}\right)$	Δn
Belgium	5.42	0.037	1.50	0.044	27.6	118.4
Finland	6.14	0.013	1.93	0.060	31.4	460.6
France	4.27	0.041	1.79	0.039	41.8	96.3
Germany	4.07	0.058	0.70	0.017	17.3	28.5
Italy	6.20	-0.005	1.03	0.041	16.6	-824.5
Netherlands	5.49	0.059	1.69	0.020	30.8	33.9
Spain	6.5	0.010	0.97	0.011	14.9	108.6
UK	7.03	0.017	0.78	0.031	11.1	183.8
Euro Mean	5.64	0.029	1.18	0.031	20.8	107.7
US						

Table 16: The First Category: Health-enhancing Leisure Time 1

Activity codes		**Description**
#	core file variable	
34	Religion (15)	worship and religious activity
35	Goout (23)	general out-of-home leisure
36	Goout (23)	attend sporting event
37	Goout (23)	cinema, theatre, opera, concert
40	Goout (23)	party, reception, social event, gambling
42	Sportex (19)	general sport or exercise
43	Sportex (19)	Walking
44	Sportex (19)	Cycling
45	Goout (23)	other out-of-doors recreation
46	Garden (10)	gardening/forage (pick mushrooms), hunt/fish
47	Petcare (11)	walk dogs
48	Leisure (24)	receive or visit friends
49	Leisure (24)	conversation (in person, phone)
50	Leisure (24)	games (social or solitary), other in-home social
51	Leisure (24)	general indoor leisure
52	Leisure (24)	artistic or musical activity
55	Leisure (24)	relax, think, do nothing
57	TVradio (20)	listen to music, ipod, CD, audio book
62	Travel (18)	no activity, recorded travel mode or change of location

Note: Categories are taken from from Table 3.1: Harmonised activity codes (69 and 25 category typologies) in Fisher, K., and J. Gershuny: "Multinational time use study: User's guide and documentation pertaining to data release 7." (2016).

Table 17: The Second Category: Health-Enhancing Leisure Time 2

Activity codes		**Description**
#	core file variable	
17	Educatn (5)	leisure course or other education or training
25	Shopserv (9)	consume personal care services
30	Ikidcare (14)	read to, talk or play with child
39	Goout (23)	restaurant, cafe bar, pub
41	Goout (23)	imputed time away from home
53	Leisure (24)	written correspondence
54	Leisure (24)	knit, crafts or hobbies
56	Read (21)	Read
58	TVradio (20)	listen to radio
59	TVradio (20)	watch TV, DVD, including web streamed content
60	Compint (22)	play computer games
65	Travel (18)	travel for voluntary/civic/religious activity
66	Travel (18)	child/adult care-related travel

Note: Categories are taken from from Table 3.1: Harmonised activity codes (69 and 25 category typologies) in Fisher, K., and J. Gershuny: "Multinational time use study: User's guide and documentation pertaining to data release 7." (2016).

Table 18: The Third Category: Personal Care

Activity codes		**Description**
#	core file variable	
1	Selfcare (3)	imputed personal or household care
2	Sleep (1)	sleep and naps
3	Sleep (1)	imputed sleep
4	Selfcare (3)	wash, dress, care for self
5	Eatdrink (2)	meals at work or school
6	Eatdrink (2)	meals or snacks in other places

Note: Categories are taken from from Table 3.1: Harmonised activity codes (69 and 25 category typologies) in Fisher, K., and J. Gershuny: "Multinational time use study: User's guide and documentation pertaining to data release 7." (2016).

Table 19: The Fourth and Fifth Categories: Working and Others (home production, etc)

Activity codes		**Description**
#	core file variable	
7	Paidwork (4)	paid work - main job (not at home)
8	Paidwork (4)	paid work at home (main, second or other job)
9	Paidwork (4)	second or other job not at home
10	Paidwork (4)	unpaid work to generate household income
11	Paidwork (4)	travel as a part of work
12	Paidwork (4)	work breaks
13	Paidwork (4)	other time at workplace
14	Paidwork (4)	look for work
15	Educatn (5)	regular schooling, education
16	Educatn (5)	Homework
18	Foodprep (6)	food preparation, cooking
19	Foodprep (6)	set table, wash/put away dishes
20	Cleanetc (7)	Cleaning
21	Cleanetc (7)	laundry, ironing, clothing repair
22	Maintain (8)	home/vehicle maintenance/improvement, collect fuel
23	Cleanetc (7)	other domestic work
24	Shopserv (9)	purchase goods
26	Shopserv (9)	consume other services
27	Petcare (11)	pet care (other than walk dog)
28	Pkidcare (13)	physical or medical child care
29	Ikidcare (14)	teach child a skill, help with homework
31	Pkidcare (13)	supervise, accompany, other child care
32	Eldcare (12)	adult care
33	Volorgwk (16)	voluntary work, civic or organisational activity
38	Goout (23)	other public event, venue
61	Compint (22)	send e-mail, surf internet, programming, computing
63	Commute (17)	travel to or from work
64	Commute (17)	education-related travel
67	Travel (18)	travel for shopping, personal or household care
68	Travel (18)	travelling for other purposes
69	Missing (25)	no recorded activity

Note: Categories are taken from from Table 3.1: Harmonised activity codes (69 and 25 category typologies) in Fisher, K., and J. Gershuny: "Multinational time use study: User's guide and documentation pertaining to data release 7." (2016).