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

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Abstract

Empirical evidence suggests that both leisure time and medical care are important inputs in health production. We present a general equilibrium model in which taxation is a key determinant of the composition of these two inputs in the endogenous accumulation of health capital. In the model, higher taxes lead to using relatively more leisure time and relatively less medical care in producing health. We find that the difference in taxation can explain a large fraction of the difference in health expenditure-GDP ratio and virtually all of the difference in time input in health production between the US and Europe. Cross-country difference in relative price of health care, although is also very important in driving difference in health expenditure-GDP ratio across countries, does not fit the data on the dimension of time allocation decision.

JEL classifications: E2; H2

Keywords: Taxation; Time input in health production; Health expenditure-GDP ratio

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1 Introduction

In the last forty 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 1970-2007 is more than 4 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 show in Section 2, the differences illustrated above, and to be documented in more details below, are beyond the counting of US-EU differences in expenditure on health-related research and development as well as on education and training of health personnel, neither are there any notable cross-country differences in aging or life-cycle dynamics, such as age structure of the population or age-related medical status and expenditure to which the differences can be attributed.

Then why do Americans spend so much more on health care than Europeans? In this paper, we highlight a channel that has not received much attention in the literature on health care costs. To this end, we develop a macroeconomic theory of health investment portfolio in a general equilibrium context. 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 will show below, ample empirical evidence reveals its critical importance in producing and maintaining good health. The thesis of our analysis is that these two inputs for health production must be jointly determined in general equilibrium and that, in the general equilibrium setting, cross-country variations in the determinants of such portfolio composition of health investments may hold a key to understanding the cross-country differences in health care expenditure.

We show that a key determinant of the composition of health investment portfolio is taxation, in particular, labor income and consumption taxes. Higher tax rates on consumption and labor imply lower opportunity costs of leisure. The main prediction of our theory is that higher taxes would lead to using relatively more leisure time and relatively less medical commodity in producing and maintaining good health. 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 much higher in the Eurozone countries than in the US, as we will document in Section 2. We find that this amount of difference in taxation as observed from the US and European data can explain nearly fifty percent of the difference in medical expenditure-GDP ratio between the US and Europe.
Out theory’s account of the US-EU differences in medical expenditure is accompanied by its prediction on cross-country differences in leisure time as the other component of an optimal health investment portfolio under different tax rates. It is important to emphasize at the outset that this portfolio view of health investment is essential for our theory’s success stated above. If we abstract from the time input in health production, as we will show below through a counterfactual experiment, higher taxes in Europe than in the US would predict that Europeans would spend a greater, rather than smaller, share of their GDP on health care than Americans.

The important question then is whether our theory’s prediction on cross-country differences in the time input for health production can find any empirical support. The theory predicts that, since labor and consumption tax rates are higher in Europe than in the US, Europeans would rely more on leisure than do Americans when it comes to producing and maintaining good health. As we will show in Section 2, this is exactly what we observe from the US and European data. We find that, in fact, the US-EU difference in taxation can explain more than ninety percent of the difference in time input in health production between Americans and Europeans.

We therefore establish that differences in taxation can provide a coherent account for much of the US-EU difference in the composition of health investment portfolio. Arising also endogenously in our general equilibrium model under different tax rates are cross-country differences in sick time as well as in paid work time, which are also consistent with the US-European comparison. The intuition for these results are as follows. The higher tax rates in Europe shall induce lower labor supply by Europeans, leaving them with more leisure time to engage in health-enhancing activities, when compared with Americans. It is then sensible for Europeans to rely more on leisure while spending less on medical goods and services than Americans when it comes to health production. Faced with lower tax rates and thus higher opportunity costs of leisure, Americans shall choose to work more and spend more on medical goods and services while having less leisure time, when compared with Europeans.

To help sharpen the main results, our analysis in the former part of this paper as described above abstracts from cross-country differences in health care prices relative to the general price levels. In actuality, the relative prices of medical goods and services are on average higher in the US than in Europe, as we will document below, and such relative price differences are often thought of as contributing significantly to the higher overall health spending by Americans than by Europeans. Therefore, in the latter part of the paper, we also examine the relative price effects viewed through the lens of our theory on health investment portfolio.

In the general equilibrium context of the present paper, two countervailing effects arise from a higher relative price of medical commodity on overall health spending:
(1) higher expenditure per unit of medical consumption, and (2) substitution away from medical commodity towards other goods and services in generating utility and towards time input in producing and maintaining good health. While the effect of (1) on overall health spending dominates that of (2), it is partially offset by the latter. This is to say that the contribution of a higher relative health price to higher overall health spending is weakened by the re-balancing of health investment portfolio. More importantly, this re-balancing implies that higher relative health care prices would lead to using relatively more of the time input and relatively less quantity of medical commodity in producing and maintaining good health.

To put this into a quantitative perspective, we fit into our model the cross-country distribution in the relative prices of health care and services as observed from the US and European data, while keeping the cross-country differences in taxation muted. This helps isolate the account of the differences in relative health care prices for the US-EU difference in the composition of health investment portfolio. We find that the relative price difference can explain about one third of the difference in overall health spending-GDP ratio between the US and Europe, but its prediction on time allocation is in the opposite direction with the US-EU comparison: it predicts that Europeans would have longer paid work time and shorter leisure time when compared to Americans, whereas as we show the opposite holds true in the data.

Finally, when we turn on the cross-country differences in taxation and in relative health care prices at the same time, our model can explain more than three fourth of the differences in overall medical expenditure-GDP ratio as well as in time input for health production between the US and Europe. We therefore argue that differences in taxation and in relative health prices jointly provide a reasonable account for the US-EU difference in the composition of health investment portfolio.

This portfolio view of health investments shed important light on the question posed at the beginning of this introduction. Our analysis recognizes the necessity of both leisure time and medical commodity in producing and maintaining good health. This permits the study of how cross-country variations in taxation and in relative health care prices may give rise to different compositions of leisure time and medical consumption in health production. To assess the quantitative significance of these effects, we hold other institutional and cultural features constant across countries.

We wish to emphasize that it is not our interpretation that these constitute all the factors for generating the cross-country differences in health care expenditure, or in time allocation, but rather we view our approach as the best way to isolate the impact of one particular channel that naturally links two apparently distinct dimensions in decision making.

The remaining of the paper is organized as follows. In Section 2, we document
the empirical evidence that motivates our study and we review the related literature. In Section 3, we present our structural model of which endogenous health investment portfolio choice is a defining feature. The model is a variant of the neoclassical growth model with taxation, augmented to include multiple uses of time that influence health production and are influenced by health status. In the model, better health reduces sick time and thus makes more of the time endowment available for paid work or leisure, while both leisure and medical care help enhance health status against the depreciation of health capital. Better health also directly increases utility, and so do greater health-neutral consumption and longer leisure time. Production of goods and physical capital accumulation are modeled in the standard ways, as in the standard neoclassical model. A government taxes consumption and labor to finance its spending. The model that is presented here is thus intended to capture some of the key incentives affected by taxation and relative prices on multiple uses of time and consumption of medical and non-medical commodities, and their interactions with endogenous health accumulation. We characterize the model’s equilibrium and discuss the implications of key first order equations. In Section 4, we describe model parametrization and report our main results. We conduct sensitivity analysis in Section 5. Finally, we provide a few concluding remarks in Section 6.

2 Empirical Evidence and Related Literature

It is a much publicized fact nowadays that Americans spend considerably more on health care than Europeans. In 2007, for instance, health care expenditure accounts for 15.7% of GDP in the US, compared with 10% in Belgium, 8.2% in Finland, 11% in France, 10.4% in Germany, 8.7% in Italy, 9.7% in Netherlands, 8.4% in Spain, and 8.4% 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 1970-2007 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.

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

\[\text{Source: OECD Health Data 2010. Data for France are available for 1970, 1975, 1980, 1985, and at annual frequency since 1990, and we have used linear interpolation to fit in missing annual data for those years between 1970 and 1990. Data for Italy are available only for years after 1988, and the number reported in Table 1 for Italy is an average for the period 1988-2007.}\]
research and development or on education and training of health personnel. There also do not seem to be any notable cross-country differences in aging or life-cycle dynamics, such as age structure of the population or age-related health status and expenditure, 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). This is consistent with the finding that differences in health care expenditures between the US and many of the European countries are similar in size across different age groups.

The point of departure of our analysis in the present 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 writings such as Grossman (1972), Gronau (1977), and Ruhm (2000), which are accompanied by many supporting empirical studies. One of such empirical studies is by Sickles and Yazbeck (1998). Using a structural model to control for endogeneity and reverse causality, whereby to also take into account the opportunity cost of leisure explicitly, these authors estimate a trans-log production function of health with both leisure time and health commodity as inputs. They find that both inputs make significantly positive contribution to good health, while the contribution of leisure can be even more than that of health-related consumption.

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, some of these

\(^2\) 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 more detail.

\(^3\) 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 can be found also in Kenkel (1995), Contoyannis and Jones (2004), and Insler (2011), among others.

\(^5\) For example, leisurely walking or cycling, exercising, vacationing, spending time in nature,
studies also show the evidence that increases in leisure time activities help reduce medical expenditures (e.g., Colditz 1999; Pratt, Macera, and Wang 2000; Wang and Brown 2004; Brown, Wang, and Safran 2005). The recent study by Pressman, Matthews, Cohen, Martire, Scheier, Baum, and Schulz (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, Ainsworth, and Godbey (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.

As is explained in the Introduction section, a key 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 second to the fourth columns of Table 1 which report the average labor and consumption tax rates, along with the corresponding tax wedge, 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, among others, Watson (1988), House, Landis, and Umberson (1988), Simon (1991), Ulrich, Simons, Losito, Fiorito, Miles, and Zelson (1991), Haskell (1994), Benca and Quintas (1997), Staats, Gatersleben, and Hartig (1997), Cohen, Doyle, Skoner, Rabin, and Gwaltney (1997), Szabo, Mesko, Caputo, and Gill (1998), Tominaga, Andow, Koyama, Numao, Kurokawa, Ojima, and Nagai (1998), Gump and Matthews (2000), Diener, Lucas, and Oishi (2002), Batty, Shipley, Marmot, and Davey (2003), Ayas, White, Al-Delaimy, Manson, Stamper, Speizer, Patel, and Hu (2003), Ayas, White, Manson, Stamper, Speizer, Malhotra, and Hu (2003), Ryff, Singer, and Dienberg (2004), Sacker and Cable (2005), and Warburton, Nicol, and Bredin (2006).

over the period 1970-2007 for the nine selected countries. The tax wedge reported in the fourth 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 now.

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 fifth column of Table, Europeans on average spend 4.3% less of their time endowment on paid work and thus 4.3% more of their time endowment is spent on leisure when compared to Americans. As a standard practice in the literature (e.g., Rogerson 2006; Ohanian, Raffo, and Rogerson 2008; Jones and Klenow 2011), time spent on paid work is here calculated as the product of total civilian employment and annual hours per worker, divided by the size of the population aged 15-64. We then divide the measure so constructed by $365 \times 16$ 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 the multi-country time-use surveys that 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 time and leisure time is thus not a simple dichotomy.

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7 Source: McDaniel (2007). The author applies the methodology in Mendoza, Razin, and Tesar (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 average labor and consumption tax rates for Italy reported in the second and third columns of Table are for the same period 1988-2007 for which the Italian health expenditure data are reported in the first column of the table. The data are downloaded from http://www.caramcnelson.com/researchpapers.

8 The data are taken from Ohanian, Raffo, and Rogerson (2008). They are the average for the period 1970-2004, except for Italy for which it is the average for the period 1988-2004.
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 accrue to the doer, but not to the hirer. Thus these
activities are all examples of personal care or leisure, which are arguably important
time inputs for the production of health.

The sixth column in Table 1 reports the sum of these two categories of time use,
which we shall refer to as time input in health production, or, with a little abuse
of terminology, leisure time for short, as a fraction of the time endowment for the
nine selected 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
health-enhancing activities than Americans. It is worth recalling that these Eurozone
countries on average spend one hour less per day on paid work than the US. Thus it
seems that Europeans shift much of this one-hour time from paid work to personal
care or leisure rather than unpaid work, when compared with Americans.

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, Reinhardt, Hussey, and Petrosyan 2003). This can be seen from
the seventh column of Table 1 which reports the purchasing power parities-adjusted
price indexes of health care goods and services in 2005 for the nine selected countries,
where the US level is normalized to 1. The data are taken from the OECD 2005
PPP Benchmark Results, in particular, Table 1.11 that is titled “Price levels for
expenditure at average OECD prices.” This is a widely used dataset for international
comparison of relative prices for health care goods and services (e.g., Pearson 2009). It

It can be inferred from this column of the table that US health care prices are about
31% higher than the European average.

results obtained here are broadly consistent with the conclusions reached in earlier studies, such as
the individual country case studies on the price level of health care conducted by McKinsey Global
Some recent studies suggest various cultural and institutional differences between the US and Europe as potentially relevant for the differences in hours worked and/or in leisure time between Americans and Europeans. These include US-EU differences in preferences (e.g., Blanchard 2004), taxation and government transfer policy (e.g., Rogerson 2001, 2004, 2006, 2008; Prescott 2004; Davis and Henrekson 2004; Ohanian et al. 2008; Olovsson 2009), union imposed regulations and the associated social multiplier through complementarities in the consumption of leisure (e.g., Alesina, Glaeser, and Sacerdote 2005), and social norms for leisure and the associated multiplicity of equilibria (e.g., Alesina, et al. 2005; Burda, Hamermesh, and Weil 2008). However, none of these studies deals with any health-related issue.

On the other hand, there is an emerging class of economic models with endogenous health accumulation. These models have been developed to help understand the rising medical expenditure in the US (e.g., Suen 2006; Hall and Jones 2007; Fonseca, Michaud, Gamama, and Kapteyn 2009), the welfare effects of proposed health care reforms (e.g., Feng 2008; Jung and Tran 2009), the implications of employer-based health care benefits in the US (e.g., Fang and Gavazza 2011; Huang and Huffman 2011), the relative importance of consumption and investment motives of demand for health (e.g., Halliday, He and Zhang 2011), and the joint cyclical properties of health care expenditure and health capital (e.g., He, Huang, and Hung 2011). However, none of these studies addresses the cross-country differences in health care expenditure or in time allocation.

3 The Model

Our analytical framework integrates endogenous health accumulation into a variant of the neoclassical growth model with taxation à la Prescott (2004), augmented to include multiple uses of time that influence health production and that are influenced by health status. This argumentation defines the key characteristics of our model, as suggested by the empirical evidence reviewed above, that is, both leisure and medical consumption are important for enhancing health status against the depreciation of health capital, which in turn affects sick time and thus the time endowment available for paid work or leisure. The linchpin of our analysis lies with taxation and relative health care prices as the key determinants of the composition of these health inputs. The model presented here is thus intended to capture key incentives affected by these determinants on multiple uses of time and consumption of medical and non-medical commodities, and their interactions with endogenous health accumulation, that are essential to address the topic at hand.

The economy is populated with a large number of identical households, a large
number of perfectly competitive firms, and a government. A representative household has one unit time endowment in each period. The length of time in period $t$ in which the household is sick ($s_t$) decreases with its stock of health capital at the beginning of the period ($h_t$), as specified by a twice-differentiable monotone function,

$$s_t = S(h_t), \quad S'(\cdot) < 0.$$  
(1)

The household can devote its non-sick time in period $t$ to either paid work ($n_t$) or leisure ($l_t$), such that,

$$n_t + l_t = 1 - s_t.$$  
(2)

This time constraint implies that the household can’t work or enjoy leisure when sick. This together with equation (1) capture Grossman’s (1972) notion of investment motive for health care, in that better health reduces sick time and thus makes more of the time endowment available for paid work or leisure.

The household derives utility from consumption of health-neutral goods ($c_t$), leisure, and health stock in period $t$ according to $U(c_t, l_t, h_t)$, which is a twice-differentiable concave function that increases in all of its arguments. The postulation that better health directly enhances household utility captures Grossman’s (1972) notion of consumption motive for health investment.

Health investment is created using health-related consumption ($m_t$) and leisure time according to $H(m_t, l_t)$, which is a twice-differentiable quasi-concave function increasing in both of its arguments. The level of health stock in period $t + 1$ is an update of period-$t$ investment in health plus undepreciated health stock from the previous period, such that,

$$h_{t+1} = (1 - \delta_h)h_t + H(m_t, l_t),$$  
(3)

where $\delta_h$ is health capital depreciation rate. This specification is a simplified version of the model estimated by Sickles and Yazbeck (1998).\footnote{Sickles and Yazbeck (1998) allow the stock of health capital at a given point in time to be affected by a distributed lag of past health stocks. Using this more general specification would not change the main results of this paper.}

The household’s budget constraint in period $t$ is given by

$$(1 + \tau_c)[c_t + p_m m_t] + k_{t+1} = (1 - \tau_n)w_t n_t + (r_t + 1 - \delta_k)k_t + \Pi_t + T_t,$$  
(4)

where $\tau_c$ and $\tau_n$ denote the tax rates on consumption and on labor income, respectively, $p_m$ denotes the relative price of medical commodity, $w_t$ is the wage rate, $r_t$ is the rate of return on the household’s rental of physical capital to firms in period...
\( t \) \((k_t)\), \( \delta_k \) is physical capital depreciation rate, and \( \Pi_t \) and \( T_t \) are respectively the profits and lump-sum transfer from firms and the government to the household.

The objective of the household is to choose the allocation of time among different uses, consumption of non-medical and medical commodities, health and physical capitals to maximize the expected, discounted lifetime utility,

\[
E \sum_{t=0}^{\infty} \beta^t U(c_t, l_t, h_t),
\]

where \( E \) is the expectations operator and \( \beta \) is a subjective discount factor, subject to (1)-(4), taking the wage and capital rental rates, the tax rates, and the initial conditions \( h_0 \) and \( k_0 \) as given.

A representative firm has a production function that generates \( F(K_t, N_t; z_t) \) units of output from \( K_t \) units of physical capital and \( N_t \) units of labor inputs, under the level of technology \( z_t \). The production function is of constant returns to scale with respect to capital and labor, and is twice-differentiable, quasi-concave, and increasing in both of these two inputs. The firm rents physical capital and hires labor services from the households to produce output. The firm’s profit in period \( t \) is

\[
\Pi_t = F(K_t, N_t; z_t) - r_t K_t - w_t N_t.
\]

The objective of the firm is to choose physical capital and labor inputs to maximize the profit in each period, taking the wage and capital rental rates as given.

To close the model, we assume without the loss of generality and insight that the government runs a balanced budget in every period and rebates all tax revenues to the households in the form of a non-distortional lump-sum transfer,

\[
\tau_c [c_t + p_m m_t] + \tau_n w_t n_t = T_t.
\]

While being kept as simple as possible, our baseline model presented above has all the necessary features to build the central mechanism that we aim to investigate. This mechanism has to do with how labor income and consumption taxes and the relative price of medical commodity affect the incentives in the allocation of time among different uses, and of expenditure on medical and non-medical commodities, and their interactions with health production. Our view is that it is important to understand the effect that taxation and relative health care price can have on the composition of time and goods inputs in the endogenous accumulation of health capital, and that our model described above provides an arguably simplest possible general equilibrium framework for conducting such an analysis.
An equilibrium for this economy consists of allocations \( n_t, l_t, s_t, c_t, m_t, h_{t+1}, \) and \( k_{t+1} \) for households, and \( N_t \) and \( K_t \) for firms, together with wage rate \( w_t \) and capital rental rate \( r_t \), for all \( t \geq 0 \), that satisfy the following conditions: (i) given the wage and capital rental rates, the allocations for households solve the utility maximization problem; (ii) given the wage and capital rental rates, the allocations for firms solve the profit maximization problem; (iii) the government budget constraint is satisfied; and (iv) markets for labor, physical capital, and goods clear.

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

\[
\tau = \frac{\tau_n + \tau_c}{1 + \tau_c},
\]

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

The Euler equation for optimal intertemporal allocation of consumption of the health-neutral commodity, through optimal accumulation in physical capital, gives rise to the following familiar condition,

\[
U_c(t) = \beta E_t [U_c(t + 1)(r_{t+1} + 1 - \delta_k)].
\]

The left-hand side of this equation is the cost of giving up one unit of consumption of the health-neutral commodity, measured in terms of (marginal) utility, where the right-hand side is the present value of expected future benefit from investing the foregone consumption goods in physical capital.

The Euler equation associated with the optimal composition of leisure time and health-related commodity inputs in health production is given by,

\[
MRS_{l,c}(t) + MRTS_{l,m}(t)p_m = (1 - \tau)w_t,
\]

where \( MRS_{l,c}(t) \equiv U_l(t)/U_c(t) \) denotes the marginal rate of substitution of leisure \( l \) for health-neutral consumption \( c \), which measures the amount of \( c \) that can be saved with an additional unit of \( l \) while maintaining the same level of utility, and \( MRTS_{l,m}(t) \equiv H_l(t)/H_m(t) \) denotes the marginal rate of technical substitution of leisure \( l \) for health-related consumption \( m \), which measures the amount of \( m \) that can be saved on with one additional unit of \( l \) while maintaining the same level of health production. The left-hand side of this equation is thus the benefit from having additional leisure, while the right-hand side of the equation is the opportunity cost of the leisure time in terms of the foregone labor income on paid work, all measured in units of the health-neutral commodity.
The Euler equation for optimal health accumulation, when combined with the condition for optimal intratemporal allocation between health-related consumption and health-neutral consumption, gives rise to the following condition,

\[
\beta E_t \left[ U_h(t + 1) - (1 - \tau)w_{t+1}S'(h_{t+1})U_c(t + 1) + (1 - \delta_h)\frac{U_c(t + 1)}{H_m(t + 1)p_m} \right] = \frac{U_c(t)}{H_m(t)p_m}.
\]

(11)

The right-hand side of this equation is the cost at date \( t \) of producing one additional unit of health capital for date \( t + 1 \) through health-related consumption, measured in terms of (marginal) utility. The left-hand side of this equation is the present value of expected future benefit, measured in terms of expected future (marginal) utilities, from having one additional unit of health capital at date \( t + 1 \). The benefit includes (i) higher utility directly derived from the additional health capital, (ii) reduced sick time due to better health status, meaning more time for paid work and thus greater labor income (which boosts consumption to increase utility), and (iii) saving on future health investment (in terms of future marginal utility) from undepreciated health capital. It is worth mentioning that (i) and (ii) generalize Grossman’s (1972) notions of consumption and investment motives for health expenditure and relate them to the household’s incentives in labor and goods markets in the presence of labor income and consumption taxes, and that the continuation value captured by (iii) indicates that the benefit from current health investment will be present for many future periods due to the incomplete depreciation of health capital.

Equations (10) and (11) hold the key to the model’s central mechanism for understanding how taxation affects the optimal composition of leisure and health-related consumption and of multiple uses of time, as they pertain to health production. As the right side of (10) shows, a higher tax wedge means a lower effective wage rate and thus a lower opportunity cost of leisure. Then, as the left side of this equation shows, more leisure time \( l \) will be used (relative to health-neutral consumption \( c \)) in maintaining utility and (relative to health-related consumption \( m \)) in producing health. The flip side of the \( l-c \) trade-off in maintaining utility and its implication for labor supply in the face of taxation are the linchpin of the analysis in Prescott (2002, 2004), Ohanian et al. (2008), and Rogerson (2008). Equation (10) generalizes their theory by adding on top of the \( l-c \) trade-off in maintaining utility, the \( l-m \) trade-off in producing health. This extension strengthens the effect of taxation on labor supply, while at the same time it provides a novel theory on how a higher tax wedge may induce the household to use relatively more leisure time and relatively less medical commodity in health production.
This extension is further enriched by another novel feature of the model, that is, health capital affects sick time and thus time available for leisure or paid work. This can be better seen by rewriting Equation (11) as follows,

$$U_c(t) = E_t \sum_{i=1}^{\infty} \beta^i (1 - \delta_h)^{i-1} [U_h(t + i) - (1 - \tau)w_{t+i}S'(h_{t+i})U_c(t + i)].$$  \hspace{1cm} (12)$$

As the second infinite-sum on the right side of this equation illustrates, a higher tax wedge weakens the investment motive for health expenditure, as the benefit from enhanced health status in terms of reduced sick time and thus increased time for paid work is reduced by the lowered effective wage rate. Then, as the left side of this equation shows, the household will consume less of the health-related commodity $m$ (while having a lower level of health production) in exchange for more health-neutral consumption $c$ (to directly boost current-period utility). This effect of taxation on the $c$-$m$ trade-off might be quantitatively significant, given that a permanently higher tax wedge will reduce the benefit (in terms of increased time available for paid work) from current health investment for many periods in the future.

In sum, in the presence of a higher tax wedge, the various optimal trade-offs embedded in conditions (10) and (11) would reinforce to generate a longer leisure time, a shorter time on paid work and a smaller health expenditure.

The optimality conditions for profit maximization are standard, given by,

$$r_t = F(k_t, n_t; z_t), \quad w_t = F_n(k_t, n_t; z_t),$$  \hspace{1cm} (13)$$

which have taken into account the market clearing conditions for physical capital, $k_t = K_t$, and for paid work time, $n_t = N_t$.

The household and government budget constraints then imply the market clearing condition for goods (i.e., the resource constraint),

$$c_t + p_m m_t + k_{t+1} - (1 - \delta_k)k_t = F(k_t, n_t; z_t).$$  \hspace{1cm} (14)$$

Equations (1)-(3) and (9)-(14) characterize an equilibrium.

4 Parametrization and Main Results

As illustrated by the analysis in Section 3, our model predicts that households would use relatively more leisure time and less medical commodity in health production, while working less for pay, when faced with a higher tax wedge. Then an interesting question would be: To what extent can the US-EU differences in taxation account
for the differences in health expenditure-GDP ratio and in leisure time between the US and the European countries? Given that this question is quantitative in nature, we need to parameterize our model in order to answer it.

### 4.1 Parametrization

To begin, we postulate the following functional form for how the stock of health capital affects sick time,

\[ S(h_t) = Q h_t^{-\gamma}, \quad (15) \]

where parameter \( \gamma \) measures the sensitivity of sick time with respect to health stock, and \( Q \) is a scaling parameter.

Then, we parameterize the health production function using a CES version of the trans-log production function of health estimated by Sickles and Yazbeck (1998),

\[ H(m_t, l_t) = \begin{cases} B[\theta m_t^{\varpi} + (1 - \theta) l_t^{\varpi}]^{\frac{1}{\varpi}} & \text{if } \varpi \neq 0, \\ B(\theta m_t^{\varpi})^{\xi} & \text{if } \varpi = 0, \end{cases} \quad (16) \]

where \( \theta \) and \( 1 - \theta \) measure respectively the shares of medical commodity and leisure time inputs in health production in the long-run stationary equilibrium, \( \varpi \) determines the elasticity of substitution between these two inputs, given by \( 1/(1-\varpi) \), \( \xi \) measures the degree of returns to scale in the health production technology, and \( B \) is a scaling parameter which represents the level of technology in health production.

Next, we parameterize the period utility function into the following form,

\[ U(c_t, l_t, h_t) = \log[\lambda c_t^{1-\eta} + (1 - \lambda) h_t^{1-\eta}] + \rho \log l_t, \quad (17) \]

where \( \lambda \) measures the importance of health-neutral consumption relative to the stock of health capital in the household’s preferences, the inverse of \( \eta \) is the elasticity of substitution between these two entries, and \( \rho \) measures the importance of leisure relative to the consumption-health bundle in the household’s preferences.

Finally, we postulate the standard Cobb-Douglas form for the production function of goods,

\[ F(K_t, N_t; z_t) = z_t K_t^\alpha N_t^{1-\alpha}, \quad (18) \]

where \( \alpha \) and \( 1 - \alpha \) measure respectively the cost shares of physical capital and labor services in the value-added productive inputs in the long-run stationary equilibrium.

In what follows in this section, we calibrate the model to the US data and compute the steady-state values for the key variables of interest (we compute the steady state...
by setting the technology level \( z_t \) to its unconditional mean of 1 and shutting off the time dimension). We then recompute the model’s equilibrium while keeping the other baseline parameter values unchanged, but replacing the labor income and consumption tax rates with those observed for each of the eight selected European countries. This will allow us to see what would happen to the US economy if it adopts the tax rates in these Eurozone countries. This will then give us a sense about the extent to which the observed difference in taxation may account for the observed difference in medical expenditure-GDP ratio, time input in health production, and time spent on paid work between the US and Europe.

To proceed, we set the share of payment to physical capital in the value-added productive factors, \( \alpha \), to 0.4, and the annual physical capital depreciation rate, \( \delta_k \), to 0.076. These are standard values used in the literature (e.g., Cooley and Prescott 1995; Nadiri and Prucha 1996; Chen, Imrohoroglu, and Imrohoroglu 2009).

Recent estimates suggest that the annual depreciation rate of health capital for the US working-age population is on average about 5.6 percent (e.g., Fonseca et al. 2009; Scholz and Seshadri 2010; Zhao 2010), so we set \( \delta_h = 0.056 \), to be consistent with these studies. In terms of selecting a value for \( \eta \), we note that its inverse measures the elasticity of substitution between health stock and non-medical good consumption in the utility function, and we set \( \eta = 8.85 \), to be consistent with the studies by Viscusi and Evans (1990), Murphy and Topel (2006), Finkelstein, Luttmer, and Notowidigdo (2010), Scholz and Seshadri (2010), and Halliday et al. (2011). Given this value, health is highly complementary to health-neutral consumption. Being healthy increases marginal utility of health-neutral consumption. We set the parameter governing the elasticity of sick time with respect to health stock \( \gamma = 1 \), and the returns-to-scale parameter for health production technology \( \xi = 1 \), following Grossman (1972), and we postulate the standard Cobb-Douglas form for the health production function by setting \( \sigma = 0.11 \).

We calibrate the effective labor income and consumption tax rates based on the data constructed by McDaniel (2007). For the US economy in the period 1970-2007,  

\[ \omega = 0.3246 \]  

which implies the elasticity between health-related consumption \( m \) and leisure time \( l \) in health production is 1.48. We then redo the exercise in Section 4.2.1. We find that with this more flexible functional form in health production technology, the taxation alone can explain about 76% of the gap in \( \frac{m}{y} \) ratio, 89% of the gap in the time input for health and 86% of the gap in working hours ratio across countries. Even when we force the share of medical expenditure \( \theta = 0.8 \), the cross-country difference in taxation is still able to explain 42% of the gap in \( \frac{m}{y} \) ratio across countries. Due to the space limit, we do not report the detailed results here.

\[ \text{We have done an experiment for testing the robustness of the results with taxation channel only to a generalized CES specification of health production function when } \omega \neq 0 \text{ as shown in equation } 14. \text{ We set share of medical expenditure } \theta = 0.5 \text{ and recalibrate the model. We obtain } \omega = 0.3246 \text{ which implies the elasticity between health-related consumption } m \text{ and leisure time } l \text{ in health production is 1.48. We then redo the exercise in Section 4.2.1. We find that with this more flexible functional form in health production technology, the taxation alone can explain about 76% of the gap in } \frac{m}{y} \text{ ratio, 89% of the gap in the time input for health and 86% of the gap in working hours ratio across countries. Even when we force the share of medical expenditure } \theta = 0.8, \text{ the cross-country difference in taxation is still able to explain 42% of the gap in } \frac{m}{y} \text{ ratio across countries. Due to the space limit, we do not report the detailed results here.} \]
the average labor income tax rate is 21 percent, so we set $\tau_n = 0.21$, and the average consumption tax rate is 8.3 percent. Given that the data do not differentiate medical expenditure from non-medical consumption, we set $\tau_c = \tau_m = 0.083$ accordingly.\(^\text{12}\) Finally, we normalize the relative price of medical care in the US $p_m$ to be one.

There are six remaining parameters in the model that need to be calibrated. They are the subjective discount factor, $\beta$, the parameter measuring the importance of non-medical consumption relative to the stock of health capital in the utility function, $\lambda$, the parameter measuring the importance of leisure relative to the consumption-health bundle in the utility function, $\rho$, the share of medical goods input in health production, $\theta$, and the two scaling parameters, $Q$ in (15) and $B$ in (16), respectively. The values for these six parameters are jointly determined by matching six relevant steady-state conditions in the model with the corresponding moment conditions for the US economy for the 1970-2007 or similar periods. These moment conditions either have already been calculated in the existing literature, or can readily be derived from available data sources. These include an annual capital-output ratio as 3.32 (e.g., Cooley and Prescott 1995; Chen et al. 2009), a medical expenditure-output ratio as 0.114 (computed from the National Health Accounts for the period 1970-2007), a non-medical consumption-output ratio as 0.634\(^\text{13}\) a ratio of working hours to total discretionary time as 0.218 (e.g., Ohanian et al. 2008), a medical expenditure-total consumption ratio as 0.15 (e.g., Huang and Huffman 2011), and a frequency of sick time as 0.021 (computed based on the data reported by Lovell 2004)\(^\text{14}\).

These baseline parameter values are summarized in Table 2.

\(^{\text{12}}\)To check the robustness of our results to this assumption, we do an additional experiment with $\tau_m = 0$ in all countries, i.e., the government intentionally makes medical care cheaper than non-medical consumption goods. In this case, cross-country difference in taxation alone (exercise in Section 4.2.1) can still capture 40% of the gap in $\frac{m}{y}$ ratio, 85% of the gap in time input for health, and 83% of the gap in labor supply between the U.S. and the eight European countries.

\(^{\text{13}}\)The ratio of total consumption to real GDP is about 0.748 for the post-war US economy (e.g., Cooley and Prescott 1995). Subtracting the medical expenditure-GDP ratio as 0.114 from this number, we arrive at a non-medical consumption-GDP ratio as 0.634.

\(^{\text{14}}\)Based on data from the National Health Interview Survey, Lovell (2004) reports that employed adults in the US miss, on average, 4.6 days of work per year due to illness or other health-related factors. Notice that this number is very close to the one reported by Ramey and Francis (2009) who use micro-level data. This translates into 2.1% of total available working days. We use this ratio as an approximation to the share of sick time in total discretionary time.
4.2 Results with Taxation Channel Only

4.2.1 Results

We now recompute the steady-state equilibrium of the model for each of the eight cases in which the labor income and consumption tax rates for the US are replaced by the tax rates for each of the eight selected European countries (again, for each case, $\tau_m$ is set equal to $\tau_c$) as in Table 11, while all of the other parameters are kept at their baseline values. In order to isolate the effect of the tax channel, we also keep the relative price of medical expenditures $p_m = 1$ for all the countries. The equilibrium medical expenditure-GDP ratio, time input in health production, and hours worked in each of the eight cases of the model can be compared with their counterparts in the baseline model for the US economy. These differences predicted by the model can then be contrasted with the corresponding differences between each of the European countries and the US observed in the data. These contrasts tell us how important a role the differences in taxation between the US and Europe alone may play in explaining their differences in these variables of interest. The results are reported in Table 3.

For example, if the average labor income and consumption tax rates in US are the same as in France for the period 1970-2007, i.e., $\tau_n = 38.3\%$, $\tau_c = 23.9\%$ and hence tax wedge $\tau = 50.2\%$, higher than the one in the US by 23.1%, the medical expenditure-output ratio would decrease 2.3% from 11.3% to 9.0% in the model, while in the data, average $m/y$ ratio in France for period 1970-2007 is 8.5%, 2.9% lower than the U.S. Therefore, difference in taxation explains about 78% of the gap in $m/y$ data between the US and France.

On the other hand, difference in taxation also affects an individual’s time allocation decision between paid work and leisure time used in producing health. The data show French spends 4% of time endowment higher in health-enhancing time input than Americans. The model predicts that with average tax rates in France, leisure time would increase 4.3% from 76.1% to 80.4%. It captures the entire gap of time input in health between two countries in the data.

Finally, average working hours ratio would decreases from 21.8% to 17.1% in the model. This 4.7% decrease also accounts for almost the entire difference in average working hours ratio between US and France for the period 1970-2004.

Overall in Table 3, the difference in $\tau_n$ and $\tau_c$ between US and the eight European

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15Since Italy only has $m/y$ ratio data for the period 1988-2007, we calibrate the US economy for the same period only for Italy. Our six targeting moments for calibration change to $k/y = 3.32$, $m/y = 13.8\%$, $c/y = 61\%$, $m/(c + m) = 16\%$, $n = 22.85\%$, and $s = 2.1\%$. Therefore, for Italy, the comparison in Table 3 is for the period 1988-2007.
countries on average is able to explain 1.9% out of 4.1% difference in medical expenditure-output ratio between US and those major European countries. In other words, the difference in taxes alone captures about 47% of the gap in medical expenditure-output ratio. It also generates 3.6% out of 4.0% difference in time input in health observed in the data. Therefore, taxation alone on average captures 91% of the gap in time input in health between the U.S. and European countries. Finally, cross-country difference in tax rates also captures on average 4.0% out of 4.4%, i.e., 90% of the gap in working hours ratio.

This result confirms the finding in Prescott (2004) and Ohanian et al. (2008) to show that the cross-country difference in taxation can almost capture the entire gap in labor supply between the U.S. and major European countries. However, beyond it we show that cross-country difference in taxation is also crucial in capturing the entire gap in time input in health and a significant part of the gap in medical expenditure-output ratio between the U.S. and European countries.

4.2.2 Counterfactual Experiment

In order to understand the economic intuition behind the results in Table 3, we run an experiment that shuts down the time input in health production by setting $\theta = 1$. The reasoning behind this experiment is following. We know higher taxes reduce labor supply and hence increase leisure. Motivated by the discussion in Section 3, we are guessing the reason why higher taxes also affect medical expenditure is exactly through this time channel. With more leisure time, individuals tend to use more leisure to produce health and hence crowd out the goods input in health production. The experiment we propose should be able to quantify the relative importance of this "crowding out" effect between the time and goods input in health production.

Keeping other parameters at their benchmark values as in Table 2, by setting $\theta = 1$, we only need to recalibrate five parameters: $\beta$, $\lambda$, $\rho$, $B$, and $Q$. Based on the results of the experiment, we can conclude that the cross-country difference in labor income tax rate is much more important in affecting the medical expenditure-output ratio than consumption tax rate.

We have also done an experiment to further decompose the effect of labor income tax rate $\tau_n$ and consumption tax rate $\tau_c$ on gap in medical expenditure-output ratio, time input for health and labor supply, respectively. In order to isolate the impact of cross-country difference in $\tau_n$, we keep $\tau_c$ at the level of U.S. for all countries. The experiment shows that cross-country difference in $\tau_n$ alone can explain 35% of the gap in medical expenditure-output ratio, 68% of the gap in time input for health, and 68% of the difference in labor supply between European countries and the U.S. On the other hand, in order to isolate the impact of cross-country difference in $\tau_c$, we keep $\tau_n$ at the level of U.S. for all countries. The experiment shows that cross-country difference in $\tau_c$ only can explain 13% of the gap in medical expenditure-output ratio, 26% of the gap in time input for health, and 25% of the difference in labor supply between European countries and the U.S. Cross-country difference in labor income tax rate is much more important in affecting cross-country difference in medical expenditure-output ratio than consumption tax rate.

We drop medical expenditure - total consumption ratio from the targeted moment conditions for calibration as mentioned in Section 4.1. The calibrated parameter values change to $\beta = 0.9574$, $\lambda = 0.0574$, $\rho = 0.9574$, $B = 0.9574$, and $Q = 0.9574$. Based on the results of the experiment, we can conclude that the cross-country difference in labor income tax rate is much more important in affecting the medical expenditure-output ratio than consumption tax rate.
on the recalibrated parameter values, we redo the exercise as in Section 4.2.1. The results are reported in Table 4.

Higher tax wedge decreases labor supply and increases leisure time significantly even when leisure is not used in health production. However, it is surprising that by eliminating time input in health production, a higher taxation actually does not reduce medical expenditure-GDP ratio as in the benchmark case but rather slightly increases it. Cross-country difference in taxation predicts that $\frac{m}{y}$ ratio should increase 0.08% on average for European countries compared to the U.S. The prediction on $\frac{m}{y}$ ratio is on the wrong direction. This exercise shows that the substitution effect between leisure time and medical expenditure is the key channel that generates the link between taxation and medical spending. Without this channel, the intratemporal condition goes back to the one in RBC model

$$MRS_{l,c}(t) \equiv \frac{U_l(t)}{U_c(t)} = (1 - \tau)w_t$$

Compared to equation (10), we see clearly the link between tax wedge $\tau$ and the $l - m$ trade-off disappears since the term $MRTS_{l,m}(t) \equiv H_l(t)/H_m(t)$ is gone. The message of this experiment is very clear: the trade-off between time and goods input in producing health is the key channel to allow tax rates affect individuals’ choice on medical care.

### 4.3 Results with Both Taxation and Relative Price Channels

As mentioned in the introduction, a popular view among health economists regarding the cross-country difference in medical expenditure-GDP ratio is that Americans face relatively more expensive price of health care goods and services. To test the importance of this channel on affecting cross-country difference in medical expenditure-GDP ratio, we input the data of cross-country difference in $p_m$ from Table 1 into the model. Therefore, we have both exogenous cross-country differences in tax rates and $p_m$. We then redo the exercise as in Section 4.2.1. The results are reported in Table 5.

With both exogenous cross-country differences in tax rates and relative price of health care, the model significantly improves its prediction power on cross-country difference in $\frac{m}{y}$ ratio. On average, the model is able to explain 3.1% out of 4.1% difference in $\frac{m}{y}$ ratio between US and major European countries. The cross-country differences in taxation and relative price of health care together capture about 76% of

$\lambda = 0.3184$, $\rho = 1.9195$, $B = 0.4087$, and $Q = 0.0085$. 

21
the gap in medical expenditure-output ratio. The prediction power increases almost 30% compared to the model with the taxation channel only. The model also does well in capturing the cross-country difference in time allocation decision. With both channels at work, the model predicts about 79% of the gap in time input in health and 75% of the gap in working hours ratio between the U.S. and European countries.

4.4 Results with Relative Price Channel Only

To isolate the effect of the cross-country difference in relative price of health care on cross-country differences in $\frac{m}{y}$ ratio and time allocation decision, we run a counterfactual experiment that only includes exogenous cross-country difference in $p_m$ into the model. In other words, $p_m$ for each country is taken from the seventh column in Table 1. However, we keep tax rates $\tau_l$, $\tau_c$ and $\tau_m$ to be constant at the U.S. level across countries. We again redo the exercise as in Section 4.2.1. The results are reported in Table 5.

With only the cross-country difference in relative price of health care, the model on average is able to explain 1.3% out of 4.1% and hence captures about 33% of the difference in $\frac{m}{y}$ ratio between US and major European countries. Relative price channel, as health economists conjecture, does significantly contribute to cross-country difference in medical expenditure-GDP ratio. The channel, however, affects the time allocation decision as well. Shown in Table 5 cross-country difference in relative price of health care induces Europeans work more and input less time in producing health. The model predicts that in European countries on average working hours ratio is 0.8% higher and time input for health is 0.7% less than the U.S., which goes against the data.

Why does the cross-country difference in relative price of health care contribute to explaining the gap in $\frac{m}{y}$ ratio but fails in other dimension? The reason lies in the intratemporal condition equation (10). Given our parameterization, let’s rewrite the equation as follows

$$\frac{U_l(t)}{U_c(t)} = (1 - \tau)w_t - p_m \frac{1 - \theta m_t}{l_t}$$

Keeping other things equal, lower $p_m$ (as in European countries) makes the medical expenditure, compared to time input for health, more attractive in health production. An individual will shift from time input $l$ to use relatively more health expenditure $m$. $p_m$ thus affects the $l - m$ trade-off in health production and in turn affects the work-leisure choice. With less demand for leisure, an individual chooses to work more and enjoy less leisure time. That’s why the relative price channel predicts that Europeans work more and input less time in producing health. The medical
expenditure-GDP ratio, however, is $\frac{p_m m}{y}$ in the model. With lower $p_m$, $m$ would be higher. But since $p_m$ also affects time allocation to induce individuals work more, keep other things equal, output $y$ would be higher. That's why the ratio $\frac{p_m m}{y}$ could decrease.

Compared the results with the relative price channel only in this section to the ones with the taxation channel only, we can conclude that although our results confirm health economists' view on the importance of the relative price channel in explaining the cross-country difference in medical expenditure-GDP ratio, the prediction of this channel on the time allocation decision, however, goes against data. While the taxation channel shows success in explaining not only the cross-country difference in medical expenditure-GDP ratio, but also in the dimension of time allocation decision.

5 Sensitivity Analysis

Section 4 shows that cross-country difference in taxation is a very important driving force behind cross-country difference in medical expenditure-GDP ratio. In this section, we run a series of experiments to check the robustness of this conclusion to an alternative specification of preference, an alternative dataset of tax rates, including capital tax, modifying model with additional time investment in health and different values of uncalibrated parameters. For each case, we recalibrate the model and redo the exercise as in Section 4.2.1.

5.1 Non-separable Leisure

Being healthier might help an individual enjoy her leisure better. In other words, leisure might be hard to separate from consumption and health in the preference. To test our results to non-separability of leisure, we change the utility function from the one in equation (17) to

$$U(c_t, l_t, h_t) = \log[\lambda(c_t^{\rho l_t^{1-\rho}})^{1-\eta} + (1 - \lambda)h_t^{1-\eta}]$$

$\frac{1}{\eta}$ now represents the elasticity of substitution between health stock and consumption-leisure combination. We recalibrate the six parameters in Table 2 to match moment conditions and redo the exercise as in Section 4.2.1. The results are reported in Table 7.

With non-separable leisure and parameter value $\eta = 8.85$ as in Table 2, health is also complementary to leisure. It makes leisure even more favorable. One can see it
clearly in intra-temporal condition equation (19). Marginal utility of leisure $U_l(t)$ is higher on the left hand side of that equation. Keep other things equal, leisure $l_t$ has to increase to make the equation hold. Working time $n_t$ and hence output $y_t$ decrease. That implies a higher $\frac{m}{y}$ ratio compared to the case with separable leisure. In other words, non-separability of leisure strengthens the explanation power in $n$ and $l$, but weakens the explanation power in $\frac{m}{y}$. Table 7 however, shows that taxation channel is still able to capture about 30% of the gap in medical expenditure-GDP ratio across countries given non-separability of leisure in the preference.

5.2 Mendoza-Razin-Tesar Tax Rates

Instead of using the data of tax rates in McDaniel (2007), we test the robustness of our results to the original series of tax rates in Mendoza, Razin, and Tesar (1994). Mendoza et al. collect data on tax revenue from OECD Revenue Statistics and income and expenditures data from national accounts. Their dataset covers the period 1965-1991 for most of OECD countries. To be consistent with our data on medical expenditure, we choose those countries reported in Table 1 except for Italy. We report Mendoza et al.’s average tax rates for period 1970-1991 in Table 8.

Inputting the MRT data into the model, we recalibrate the six parameters to match moment conditions for period 1970-1991 and redo the exercise as in Section 4.2.1. The results are reported in Table 9. Although we use different tax rates and target on different period, Table 9 shows the results are quite close to the ones in Table 3. The difference in taxation explains on average 51% of the difference in $\frac{m}{y}$ ratio across countries.

5.3 Including Capital Tax

Capital tax is quite common in all the OECD countries. According to data from McDaniel (2007), in contrast to labor income and consumption tax rates, most European countries impose lower capital tax rate than US. Table 10 reports average capital tax rate for period 1970-2007 (with exception of Italy which covers the period 1988-2007).

Adding the capital taxes into the model, we recalibrate the six parameters and redo the exercise as in Section 4.2.1. Table 11 shows the results. It does not change the results in Table 3 significantly. The intuition is clear. Since capital tax rate $\tau_k$ does not enter into the key intratemporal equation which governs the time allocation (equation 10), it does not affect time allocation between labor supply and

\footnote{Data of $\tau_n$ for Spain is from 1980 to 1986. Data of $\tau_c$ for Spain is from 1980 to 1991.}
leisure. Therefore it has no significant impact on medical expenditure since we have already shown in Section 4.2.2 that the key channel to affect $\frac{m}{y}$ ratio is through the substitution between leisure and medical spending in health production.\footnote{It slightly improves the explanation power of difference in taxation on the gap of $\frac{m}{y}$ ratio by about 2%. Lower capital tax rates in European countries induce a relative higher return to physical capital and hence make physical capital accumulation more attractive compared to health capital accumulation. This effect further decreases the demand for medical expenditures in European countries and reinforces the effect of taxation via the time channel.}

### 5.4 Differentiate Time Investment in Health

Although our assumption of using leisure in producing health seems very reasonable, one might argue time input in health production technology indeed is a subset of non-working time. In other words, individuals only use part of leisure time in producing health. Examples include time for working out in gym, time for relaxing and taking rest, and time spent in hospital. A way to model that is to distinguish the time investment in health, called it $v$, and health-neutral leisure time $l$, which still enters into preference but would not directly affect health, in the time constraint

$$n_t + s_t + v_t + l_t = 1$$

We now use both $m$ and $v$ to produce health

$$h_{t+1} = (1 - \delta_h) h_t + B(m_t^q v_t^{1-q})$$

And both $l$ and $v$ enter into the utility function:\footnote{We have to differentiate $v$ and $l$ in the preference by giving them different weights. Otherwise if they are perfectly substitutable to each other in both preference and time constraint and $v$ has the additional benefit to improve health, time input for health $v$ will strictly dominate health-neutral leisure time $l$, an individual will optimally choose zero leisure $l = 0$ and put all non-working non-sick time in $v$. The model thus reduces to the benchmark model as in Section 3.}

$$U(c_t, v_t, l_t, h_t) = \log\left[\lambda c_t^{1-\eta} + (1 - \lambda) h_t^{1-\eta}\right] + \rho \log l_t + \phi \log v_t$$
The representative agent’s problem thus changes to

\[
\max \sum_{t=0}^{\infty} \beta^t U(c_t, v_t, l_t, h_t)
\]

subject to

\[
(1 + \tau_c) c_t + (1 + \tau_m) p_m m_t + i_t \leq (1 - \tau_n) w_t n_t + r_t k_t + T_t
\]

\[
k_{t+1} = (1 - \delta_k) k_t + i_t
\]

\[
h_{t+1} = (1 - \delta_h) h_t + B(m_t^\theta \nu_t^{1-\theta})^\xi
\]

\[
n_t + v_t + l_t + s_t = 1, \quad s_t = Q h_t^{-\gamma}
\]

\[
c_t, k_{t+1} \geq 0, \quad k_0, h_0 \text{ given}
\]

With this modification, we add in another parameter, namely the weight of time input for health \( \phi \), to the parameters in the model. We look at American Time Use Survey (ATUS) and find that three activities in ATUS fits our definition of time investment in health: socializing, relaxing, and leisure; exercise through sports or recreation; and using medical services. They account for 19%, 1.2% and 0.2% of the 24-hour time endowment, respectively for the time period 2003-2007 (see Edwards 2011 for details), which is quite consistent with the narrowly defined leisure time in the multi-country time use survey (in the survey, Americans spend on average 20% of their time endowment in leisure). Therefore we can use that category in the time-use survey for the proxy of the data of time investment in health \( v \) for different countries. We calibrate \( \phi \) to match \( v = 20\% \) in the U.S. economy. We also recalibrate the six parameters \( \beta, \lambda, \rho, B, \theta, \) and \( Q \) to match the six moment conditions as described in Section 4.1. We then redo the cross-country comparison exercise in Section 4.2.1. Table 12 summarizes the results.

Compared to the results in Table 3 in the current model, the difference in tax rates of \( \tau_n \) and \( \tau_c \) can still explain a significant part (30%) of the gap in \( \frac{m}{y} \) ratio between the U.S. and European countries. It also captures about 50% of the gap in narrowly defined leisure time and maintains the success in replicating the whole gap in labor supply.

By shutting down leisure \( l \) in health production technology, we also shut off the time channel and the trade-off between medical expenditure and time input in the intratemporal condition. This condition now goes back to the one in RBC model

\[
MRS_{l,c}(t) \equiv \frac{U_l(t)}{U_c(t)} = (1 - \tau) w_t
\]

However, time use in \( v \) provides another intratemporal condition which governs the
optimal allocation of time input in health

\[ MRS_{v,c}(t) + MRTS_{v,m}(t)q_{m,c} = (1 - \tau)w_t \]  

(21)

where \( MRS_{v,c}(t) \equiv \frac{U_v(t)}{U_c(t)} \) denotes the marginal rate of substitution of narrowly defined time input in health \( v \) for health-neutral consumption \( c \), and \( MRTS_{v,m}(t) \) is the marginal rate of technical substitution of \( v \) for health-related consumption \( m \), which in turn is determined by the ratio between the marginal product of narrowly defined time input \( v \) and the marginal product of medical expenditures \( m \) in health production. An individual has to make sure that the marginal benefit of investing one unit of time in health, which involves two trade-offs: one is she loses one unit of working time for enjoying leisure, second is she loses one unit of working time for investing in health production which otherwise she can use the labor income to buy medical expenditure to enhance her health, is equal to the opportunity cost of this one unit of time in terms of wage. Although we lose the direct link between the tax wedge \( \tau \) and the trade-off between \( m \) and \( l \) as described in equation (10) for the benchmark model, equation (21) brings another trade-off. Under the functional forms we use, \( MRTS_{v,m}(t) \equiv \frac{MPV_t}{MPM_t} = \frac{1 - \theta m_t}{\theta v_t} \), we have instead the trade-off between \( m \) and \( v \). Therefore when \( \tau \) is higher, keep other things equal, equation (21) implies \( MRTS_{v,m}(t) \) and hence \( \frac{m_t}{v_t} \) goes down. In other words, an individual still wants to substitute time input \( v \) for medical care \( m \) in producing health when faces a higher tax wedge.

5.5 Depreciation Rate of Health

We pick the depreciation rate of health stock \( \delta_h = 5.6\% \) from Scholz and Seshadri (2010) who calibrated the value. A strand of literature in biology that studies natural aging of human body finds that the natural depreciation rate of health is about 3-4% per year (Dalgaard and Strulik 2010). To check the robustness of our results to the different value of \( \delta_h \), we choose \( \delta_h = 4\% \) and redo the exercise in Section 4.2.1. The results are reported in Table 13. Changing natural depreciation rate of health stock to 4% does not significantly affect the model prediction on \( \frac{m}{y} \) ratios, leisure and labor supply.\(^{21}\)

\(^{21}\)Keep other things equal, lower depreciation rate of health increases the “continuation” term in the intertemporal condition for health expenditure equation (11). Therefore it raises the relative demand for medical expenditures and hence dampens the effect of time channel on \( \frac{m}{y} \) ratio. That’s why the explanation power of the difference in taxation on \( \frac{m}{y} \) ratio decreases in this exercise.
5.6 Elasticity of Sick Time to Health

We take elasticity of sick time to health stock $\gamma = 1$ as suggested by Grossman (1972). This parameter determines the magnitude of the investment motive in the intertemporal condition (11). Grossman (1972) however did not calibrate it to match data. Halliday, He and Zhang (2011) calibrate this parameter to match the increasing trend of sick time over life cycle. Their calibration ends up with $\gamma = 2.5$. As a robustness check, we take their value and redo the exercise in Section 4.2.1. The results are reported in Table 14. Given a quite different value of $\gamma$, cross-country difference in taxation alone is still able to capture about 31% of the gap in $m_y$ ratio, 78% of the gap in time input for health and 92% for labor supply across countries.\textsuperscript{22}

6 Conclusion

Over the past forty years, although rising medical expenditure is a world phenomenon, US constantly exhibits much higher medical expenditure-output ratio than European countries. Why do Americans spend much more in medical care than Europeans? This paper argues the cross-country difference in taxation, especially labor income and consumption tax rates, is a key element to understand the gap in medical expenditures-GDP ratio between US and major European countries. Higher tax rates widen tax wedge in the key intratemporal equation that governs the time allocation between market work and leisure and hence reduces labor supply. With more leisure time, individuals tend to use relatively more time input and relatively less medical spending in producing health. Using a neoclassical growth model with endogenous health accumulation, the paper quantitatively shows that difference in labor income and consumption tax rates alone can explain a large fraction of the difference in health expenditure-GDP ratio and virtually all of the difference in time input in health production between the US and Europe. Taxation not only matters in explaining cross-country differences in hours worked as shown in Prescott (2004) and Ohanian et al. (2008), but also matters in explaining cross-country differences in medical expenditure-GDP ratio.

\textsuperscript{22}Keep other things equal, higher $\gamma$ increases the magnitude of $\frac{\partial m_{t+1}}{\partial r_{t+1}}$ and hence the investment motive term in the intertemporal condition for health expenditure equation (11). Therefore it again raises the relative demand for medical expenditures and hence dampens the effect of time channel on $\frac{m_y}{y}$ ratio like higher $\delta_h$ does. That’s why the explanation power of the difference in taxation on $\frac{m_y}{y}$ ratio also decreases in this exercise.
References


<table>
<thead>
<tr>
<th>Countries</th>
<th>( M ) (%)</th>
<th>( \tau_n ) (%)</th>
<th>( \tau_c ) (%)</th>
<th>( \tau ) (%)</th>
<th>( n ) (%)</th>
<th>h time (%)</th>
<th>( p_m )</th>
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Table 1: Average medical Expenditure-GDP ratio, tax rates, labor supply, time input for health, and relative price of health care: selected countries 1970-2007
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<th>Parameter</th>
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<th>Value</th>
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<td>0.9574</td>
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<td>$\eta$</td>
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<td>8.85</td>
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<tr>
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<td>0.2650</td>
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</tr>
<tr>
<td>$\rho$</td>
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<td>0.40</td>
<td>Cooley &amp; Prescott (1995)</td>
</tr>
<tr>
<td>$\delta_k$</td>
<td>dep. rate of capital</td>
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<td>Cooley &amp; Prescott (1995)</td>
</tr>
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<td>$\delta_h$</td>
<td>dep. rate of health</td>
<td>0.056</td>
<td>Scholz and Seshadri (2010)</td>
</tr>
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<td>$B$</td>
<td>productivity of health technology</td>
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<td>calibrated</td>
</tr>
<tr>
<td>$\theta$</td>
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</tr>
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</tr>
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<td>$\phi_m$</td>
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<td>normalization</td>
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Table 2: Parameters of the model
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<tr>
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<th>$\frac{\Delta m}{n}$ Model</th>
<th>Exp</th>
<th>$\frac{\Delta l}{n}$ Data</th>
<th>$\frac{\Delta l}{n}$ Model</th>
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<th>$\frac{\Delta n}{n}$ Data</th>
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<td>-0.0232</td>
<td>58%</td>
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<td>0.0439</td>
<td>63%</td>
<td>-0.052</td>
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<tr>
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<td>-0.0216</td>
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<tr>
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<td>0.0429</td>
<td>107%</td>
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</tr>
<tr>
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<td>-0.0207</td>
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<td>0.0394</td>
<td>79%</td>
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<td>0.0198</td>
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Table 3: m/y ratio, time input for health and labor supply: cross-country comparison with taxation channel only
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<th>( \frac{\Delta m}{m} ) Data</th>
<th>( \frac{\Delta m}{m} ) Model</th>
<th>Exp</th>
<th>( \Delta l ) Data</th>
<th>( \Delta l ) Model</th>
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<th>( \Delta n ) Data</th>
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<td>120%</td>
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<td>125%</td>
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Table 4: Taxation, m/y ratio, time input for health and labor supply: cross-country comparison when \( \theta = 1 \)
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<th>(\Delta m_y) Data</th>
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<th>Exp</th>
<th>(\Delta l) Data</th>
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Table 5: m/y ratio, time input for health and labor supply: cross-country comparison with both taxation and relative price channels
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<th>$\Delta l$ Model</th>
<th>Exp</th>
<th>$\Delta n$ Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>0.768</td>
<td>-0.040</td>
<td>-0.0127</td>
<td>32%</td>
<td>0.07</td>
<td>-0.0062</td>
<td>-9%</td>
<td>-0.052</td>
</tr>
<tr>
<td>Finland</td>
<td>0.896</td>
<td>-0.042</td>
<td>-0.0054</td>
<td>13%</td>
<td>0.04</td>
<td>-0.0026</td>
<td>-7%</td>
<td>-0.015</td>
</tr>
<tr>
<td>France</td>
<td>0.760</td>
<td>-0.029</td>
<td>-0.0132</td>
<td>46%</td>
<td>0.04</td>
<td>-0.0064</td>
<td>-16%</td>
<td>-0.049</td>
</tr>
<tr>
<td>Germany</td>
<td>0.712</td>
<td>-0.023</td>
<td>-0.0162</td>
<td>70%</td>
<td>0.05</td>
<td>-0.008</td>
<td>-16%</td>
<td>-0.038</td>
</tr>
<tr>
<td>Italy*</td>
<td>0.880</td>
<td>-0.058</td>
<td>-0.007</td>
<td>12%</td>
<td>0.03</td>
<td>-0.0033</td>
<td>-11%</td>
<td>-0.079</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.704</td>
<td>-0.034</td>
<td>-0.0167</td>
<td>49%</td>
<td>0.04</td>
<td>-0.0082</td>
<td>-21%</td>
<td>-0.060</td>
</tr>
<tr>
<td>Spain</td>
<td>0.592</td>
<td>-0.052</td>
<td>-0.0243</td>
<td>47%</td>
<td>0.03</td>
<td>-0.0123</td>
<td>-41%</td>
<td>-0.048</td>
</tr>
<tr>
<td>UK</td>
<td>0.784</td>
<td>-0.051</td>
<td>-0.0118</td>
<td>23%</td>
<td>0.02</td>
<td>-0.0057</td>
<td>-29%</td>
<td>-0.013</td>
</tr>
<tr>
<td>average</td>
<td>0.762</td>
<td>-0.041</td>
<td>-0.0134</td>
<td>33%</td>
<td>0.04</td>
<td>-0.0066</td>
<td>-16%</td>
<td>-0.044</td>
</tr>
</tbody>
</table>

Table 6: $m/y$ ratio, time input for health and labor supply: cross-country comparison with relative price channel only
<table>
<thead>
<tr>
<th>Countries</th>
<th>$\tau$</th>
<th>$\frac{\Delta \mu}{\mu}$ Data</th>
<th>$\frac{\Delta \mu}{\mu}$ Model</th>
<th>Exp</th>
<th>$\Delta l$ Data</th>
<th>$\Delta l$ Model</th>
<th>Exp</th>
<th>$\Delta n$ Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>50.7%</td>
<td>-0.040</td>
<td>-0.0146</td>
<td>37%</td>
<td>0.07</td>
<td>0.0559</td>
<td>80%</td>
<td>-0.052</td>
</tr>
<tr>
<td>Finland</td>
<td>49.1%</td>
<td>-0.042</td>
<td>-0.0135</td>
<td>32%</td>
<td>0.04</td>
<td>0.0521</td>
<td>130%</td>
<td>-0.015</td>
</tr>
<tr>
<td>France</td>
<td>50.2%</td>
<td>-0.029</td>
<td>-0.0142</td>
<td>49%</td>
<td>0.04</td>
<td>0.0546</td>
<td>137%</td>
<td>-0.049</td>
</tr>
<tr>
<td>Germany</td>
<td>48.4%</td>
<td>-0.023</td>
<td>-0.013</td>
<td>57%</td>
<td>0.05</td>
<td>0.0502</td>
<td>100%</td>
<td>-0.038</td>
</tr>
<tr>
<td>Italy*</td>
<td>49.3%</td>
<td>-0.058</td>
<td>-0.0148</td>
<td>26%</td>
<td>0.03</td>
<td>0.0526</td>
<td>175%</td>
<td>-0.079</td>
</tr>
<tr>
<td>Netherlands</td>
<td>51.6%</td>
<td>-0.034</td>
<td>-0.0152</td>
<td>45%</td>
<td>0.04</td>
<td>0.0581</td>
<td>145%</td>
<td>-0.060</td>
</tr>
<tr>
<td>Spain</td>
<td>36.9%</td>
<td>-0.052</td>
<td>-0.0056</td>
<td>11%</td>
<td>0.03</td>
<td>0.0224</td>
<td>75%</td>
<td>-0.048</td>
</tr>
<tr>
<td>UK</td>
<td>38.3%</td>
<td>-0.051</td>
<td>-0.0064</td>
<td>13%</td>
<td>0.02</td>
<td>0.0254</td>
<td>127%</td>
<td>-0.013</td>
</tr>
<tr>
<td>average</td>
<td>48.2%</td>
<td>-0.041</td>
<td>-0.0122</td>
<td>30%</td>
<td>0.04</td>
<td>0.0464</td>
<td>116%</td>
<td>-0.044</td>
</tr>
</tbody>
</table>

Table 7: Taxation, m/y ratio, time input for health and labor supply: cross-country comparison with non-seperable leisure
<table>
<thead>
<tr>
<th>Countries</th>
<th>$\tau_n$</th>
<th>$\tau_c$</th>
<th>$\tau$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>42.6%</td>
<td>17.2%</td>
<td>51.0%</td>
</tr>
<tr>
<td>Finland</td>
<td>30.8%</td>
<td>26.4%</td>
<td>45.3%</td>
</tr>
<tr>
<td>France</td>
<td>39.7%</td>
<td>20.8%</td>
<td>50.1%</td>
</tr>
<tr>
<td>Germany</td>
<td>38.3%</td>
<td>15.7%</td>
<td>46.7%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>51.9%</td>
<td>17.5%</td>
<td>59.1%</td>
</tr>
<tr>
<td>Spain</td>
<td>32.6%</td>
<td>10.1%</td>
<td>38.8%</td>
</tr>
<tr>
<td>UK</td>
<td>26.0%</td>
<td>14.8%</td>
<td>35.5%</td>
</tr>
<tr>
<td>Euro Mean</td>
<td>37.4%</td>
<td>17.5%</td>
<td>46.6%</td>
</tr>
<tr>
<td>US</td>
<td>26.5%</td>
<td>5.5%</td>
<td>30.3%</td>
</tr>
</tbody>
</table>

Table 8: Tax rates and tax wedge: MRT data, 1970-1991
<table>
<thead>
<tr>
<th>Countries</th>
<th>$\tau$</th>
<th>$\frac{\Delta m}{m}$ Data</th>
<th>$\frac{\Delta m}{m}$ Model</th>
<th>Exp</th>
<th>$\Delta l$ Data</th>
<th>$\Delta l$ Model</th>
<th>Exp</th>
<th>$\Delta n$ Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>50.7%</td>
<td>-0.028</td>
<td>-0.019</td>
<td>48%</td>
<td>0.07</td>
<td>0.0389</td>
<td>56%</td>
<td>-0.042</td>
</tr>
<tr>
<td>Finland</td>
<td>49.1%</td>
<td>-0.032</td>
<td>-0.0134</td>
<td>32%</td>
<td>0.04</td>
<td>0.0274</td>
<td>69%</td>
<td>+0.002</td>
</tr>
<tr>
<td>France</td>
<td>50.2%</td>
<td>-0.028</td>
<td>-0.0181</td>
<td>62%</td>
<td>0.04</td>
<td>0.037</td>
<td>93%</td>
<td>-0.034</td>
</tr>
<tr>
<td>Germany</td>
<td>48.4%</td>
<td>-0.023</td>
<td>-0.0147</td>
<td>64%</td>
<td>0.05</td>
<td>0.0302</td>
<td>60%</td>
<td>-0.021</td>
</tr>
<tr>
<td>Netherlands</td>
<td>51.6%</td>
<td>-0.013</td>
<td>-0.0275</td>
<td>81%</td>
<td>0.04</td>
<td>0.0559</td>
<td>140%</td>
<td>-0.055</td>
</tr>
<tr>
<td>Spain</td>
<td>38.8%</td>
<td>-0.042</td>
<td>-0.0073</td>
<td>14%</td>
<td>0.03</td>
<td>0.0151</td>
<td>50%</td>
<td>-0.036</td>
</tr>
<tr>
<td>UK</td>
<td>38.3%</td>
<td>-0.039</td>
<td>-0.0045</td>
<td>9%</td>
<td>0.02</td>
<td>0.0092</td>
<td>46%</td>
<td>-0.002</td>
</tr>
<tr>
<td>average</td>
<td>46.6%</td>
<td>-0.029</td>
<td>-0.0149</td>
<td>51%</td>
<td>0.04</td>
<td>0.0305</td>
<td>74%</td>
<td>-0.025</td>
</tr>
</tbody>
</table>

Table 9: Taxation, m/y ratio, time input for health and labor supply: MRT tax rates
<table>
<thead>
<tr>
<th>Countries</th>
<th>( t_k )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>22.3%</td>
</tr>
<tr>
<td>Finland</td>
<td>22.8%</td>
</tr>
<tr>
<td>France</td>
<td>15.5%</td>
</tr>
<tr>
<td>Germany</td>
<td>16.0%</td>
</tr>
<tr>
<td>Italy*</td>
<td>20.2%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>17.8%</td>
</tr>
<tr>
<td>Spain</td>
<td>13.2%</td>
</tr>
<tr>
<td>UK</td>
<td>29.7%</td>
</tr>
<tr>
<td>Euro Mean</td>
<td>19.7%</td>
</tr>
<tr>
<td>US</td>
<td>28.5%</td>
</tr>
</tbody>
</table>

Table 10: Capital tax rates: selected countries, 1970-2007
<table>
<thead>
<tr>
<th>Countries</th>
<th>$\tau_k$</th>
<th>$\frac{\Delta m}{y}$ Data</th>
<th>$\frac{\Delta m}{y}$ Model</th>
<th>Exp</th>
<th>$\Delta l$ Data</th>
<th>$\Delta l$ Model</th>
<th>Exp</th>
<th>$\Delta n$ Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>22.3%</td>
<td>-0.040</td>
<td>-0.0241</td>
<td>60%</td>
<td>0.07</td>
<td>0.044</td>
<td>63%</td>
<td>-0.052</td>
</tr>
<tr>
<td>Finland</td>
<td>22.8%</td>
<td>-0.042</td>
<td>-0.0224</td>
<td>53%</td>
<td>0.04</td>
<td>0.0411</td>
<td>103%</td>
<td>-0.015</td>
</tr>
<tr>
<td>France</td>
<td>15.5%</td>
<td>-0.029</td>
<td>-0.0234</td>
<td>81%</td>
<td>0.04</td>
<td>0.0402</td>
<td>101%</td>
<td>-0.049</td>
</tr>
<tr>
<td>Germany</td>
<td>16.0%</td>
<td>-0.023</td>
<td>-0.0214</td>
<td>93%</td>
<td>0.05</td>
<td>0.0366</td>
<td>73%</td>
<td>-0.038</td>
</tr>
<tr>
<td>Italy*</td>
<td>20.2%</td>
<td>-0.058</td>
<td>-0.0241</td>
<td>42%</td>
<td>0.03</td>
<td>0.0425</td>
<td>142%</td>
<td>-0.079</td>
</tr>
<tr>
<td>Netherlands</td>
<td>17.8%</td>
<td>-0.034</td>
<td>-0.0249</td>
<td>73%</td>
<td>0.04</td>
<td>0.0441</td>
<td>110%</td>
<td>-0.060</td>
</tr>
<tr>
<td>Spain</td>
<td>13.2%</td>
<td>-0.052</td>
<td>-0.0093</td>
<td>18%</td>
<td>0.03</td>
<td>0.0115</td>
<td>38%</td>
<td>-0.048</td>
</tr>
<tr>
<td>UK</td>
<td>29.7%</td>
<td>-0.051</td>
<td>-0.0111</td>
<td>22%</td>
<td>0.02</td>
<td>0.0213</td>
<td>107%</td>
<td>-0.013</td>
</tr>
<tr>
<td>average</td>
<td>19.7%</td>
<td>-0.041</td>
<td>-0.0201</td>
<td>49%</td>
<td>0.04</td>
<td>0.0352</td>
<td>88%</td>
<td>-0.044</td>
</tr>
</tbody>
</table>

Table 11: Taxation, $m/y$ ratio, time input for health and labor supply: including capital tax
<table>
<thead>
<tr>
<th>Countries</th>
<th>τ</th>
<th>$\Delta \omega_y^{\text{Data}}$</th>
<th>$\Delta \omega_y^{\text{Model}}$</th>
<th>Exp</th>
<th>$\Delta \nu^{\text{Data}}$</th>
<th>$\Delta \nu^{\text{Model}}$</th>
<th>Exp</th>
<th>$\Delta n^{\text{Data}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>50.7%</td>
<td>-0.040</td>
<td>0.0149</td>
<td>37%</td>
<td>0.03</td>
<td>0.0098</td>
<td>33%</td>
<td>-0.052</td>
</tr>
<tr>
<td>Finland</td>
<td>49.1%</td>
<td>-0.042</td>
<td>0.0139</td>
<td>33%</td>
<td>0.04</td>
<td>0.0092</td>
<td>23%</td>
<td>-0.015</td>
</tr>
<tr>
<td>France</td>
<td>50.2%</td>
<td>-0.029</td>
<td>0.0146</td>
<td>50%</td>
<td>-0.03</td>
<td>0.0096</td>
<td>-32%</td>
<td>-0.049</td>
</tr>
<tr>
<td>Germany</td>
<td>48.4%</td>
<td>-0.023</td>
<td>0.0133</td>
<td>58%</td>
<td>0.04</td>
<td>0.0089</td>
<td>22%</td>
<td>-0.038</td>
</tr>
<tr>
<td>Italy*</td>
<td>49.3%</td>
<td>-0.058</td>
<td>0.0151</td>
<td>26%</td>
<td>0</td>
<td>0.0092</td>
<td>0%</td>
<td>-0.079</td>
</tr>
<tr>
<td>Netherlands</td>
<td>51.6%</td>
<td>-0.034</td>
<td>0.0156</td>
<td>46%</td>
<td>0.02</td>
<td>0.0102</td>
<td>51%</td>
<td>-0.060</td>
</tr>
<tr>
<td>Spain</td>
<td>36.9%</td>
<td>-0.052</td>
<td>0.0058</td>
<td>11%</td>
<td>0.01</td>
<td>0.0041</td>
<td>41%</td>
<td>-0.048</td>
</tr>
<tr>
<td>UK</td>
<td>38.3%</td>
<td>-0.051</td>
<td>0.0066</td>
<td>13%</td>
<td>0.02</td>
<td>0.0046</td>
<td>23%</td>
<td>-0.013</td>
</tr>
<tr>
<td>average</td>
<td>48.2%</td>
<td>-0.041</td>
<td>0.0125</td>
<td>30%</td>
<td>0.016</td>
<td>0.0082</td>
<td>50%</td>
<td>-0.044</td>
</tr>
</tbody>
</table>

Table 12: Taxation, m/y ratio, time input for health and labor supply: differentiate time input for health
<table>
<thead>
<tr>
<th>Countries</th>
<th>$\tau$</th>
<th>$\frac{\Delta m}{m}$ Data</th>
<th>$\frac{\Delta m}{m}$ Model</th>
<th>Exp</th>
<th>$\Delta l$ Data</th>
<th>$\Delta l$ Model</th>
<th>Exp</th>
<th>$\Delta n$ Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>50.7%</td>
<td>-0.040</td>
<td>-0.0205</td>
<td>51%</td>
<td>0.07</td>
<td>0.0449</td>
<td>64%</td>
<td>-0.052</td>
</tr>
<tr>
<td>Finland</td>
<td>49.1%</td>
<td>-0.042</td>
<td>-0.0190</td>
<td>45%</td>
<td>0.04</td>
<td>0.0419</td>
<td>105%</td>
<td>-0.015</td>
</tr>
<tr>
<td>France</td>
<td>50.2%</td>
<td>-0.029</td>
<td>-0.02</td>
<td>69%</td>
<td>0.04</td>
<td>0.0439</td>
<td>110%</td>
<td>-0.049</td>
</tr>
<tr>
<td>Germany</td>
<td>48.4%</td>
<td>-0.023</td>
<td>-0.0183</td>
<td>80%</td>
<td>0.05</td>
<td>0.0403</td>
<td>81%</td>
<td>-0.038</td>
</tr>
<tr>
<td>Italy*</td>
<td>49.3%</td>
<td>-0.058</td>
<td>-0.0189</td>
<td>33%</td>
<td>0.03</td>
<td>0.0435</td>
<td>145%</td>
<td>-0.079</td>
</tr>
<tr>
<td>Netherlands</td>
<td>51.6%</td>
<td>-0.034</td>
<td>-0.0213</td>
<td>63%</td>
<td>0.04</td>
<td>0.0466</td>
<td>117%</td>
<td>-0.060</td>
</tr>
<tr>
<td>Spain</td>
<td>36.9%</td>
<td>-0.052</td>
<td>-0.008</td>
<td>15%</td>
<td>0.03</td>
<td>0.018</td>
<td>60%</td>
<td>-0.048</td>
</tr>
<tr>
<td>UK</td>
<td>38.3%</td>
<td>-0.051</td>
<td>-0.0091</td>
<td>18%</td>
<td>0.02</td>
<td>0.0203</td>
<td>102%</td>
<td>-0.013</td>
</tr>
<tr>
<td>average</td>
<td>48.2%</td>
<td>-0.041</td>
<td>-0.0169</td>
<td>41%</td>
<td>0.04</td>
<td>0.0374</td>
<td>94%</td>
<td>-0.044</td>
</tr>
</tbody>
</table>

Table 13: Taxation, m/y ratio, time input for health and labor supply: different depreciation rate of health
<table>
<thead>
<tr>
<th>Countries</th>
<th>$\tau$</th>
<th>$\frac{\Delta m}{y}$ Data</th>
<th>$\frac{\Delta m}{y}$ Model</th>
<th>$\Delta l$ Data</th>
<th>$\Delta l$ Model</th>
<th>$\text{Exp}$</th>
<th>$\Delta n$ Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>50.7%</td>
<td>-0.040</td>
<td>-0.0145</td>
<td>36%</td>
<td>0.07</td>
<td>0.037</td>
<td>53%</td>
</tr>
<tr>
<td>Finland</td>
<td>49.1%</td>
<td>-0.042</td>
<td>-0.0136</td>
<td>32%</td>
<td>0.04</td>
<td>0.0348</td>
<td>87%</td>
</tr>
<tr>
<td>France</td>
<td>50.2%</td>
<td>-0.029</td>
<td>-0.0142</td>
<td>49%</td>
<td>0.04</td>
<td>0.0363</td>
<td>91%</td>
</tr>
<tr>
<td>Germany</td>
<td>48.4%</td>
<td>-0.023</td>
<td>-0.0131</td>
<td>57%</td>
<td>0.05</td>
<td>0.0336</td>
<td>67%</td>
</tr>
<tr>
<td>Italy*</td>
<td>49.3%</td>
<td>-0.058</td>
<td>-0.0174</td>
<td>30%</td>
<td>0.03</td>
<td>0.0356</td>
<td>119%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>51.6%</td>
<td>-0.034</td>
<td>-0.0151</td>
<td>44%</td>
<td>0.04</td>
<td>0.0383</td>
<td>96%</td>
</tr>
<tr>
<td>Spain</td>
<td>36.9%</td>
<td>-0.052</td>
<td>-0.0060</td>
<td>12%</td>
<td>0.03</td>
<td>0.0157</td>
<td>52%</td>
</tr>
<tr>
<td>UK</td>
<td>38.3%</td>
<td>-0.051</td>
<td>-0.0067</td>
<td>13%</td>
<td>0.02</td>
<td>0.0177</td>
<td>89%</td>
</tr>
<tr>
<td>average</td>
<td>48.2%</td>
<td>-0.041</td>
<td>-0.0126</td>
<td>31%</td>
<td>0.04</td>
<td>0.0311</td>
<td>78%</td>
</tr>
</tbody>
</table>

Table 14: Taxation, m/y ratio, time input for health and labor supply: different gamma