Health, Working Time and Growth: The American Puzzle

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Abstract

Since the 1980s, the US follows a different growth path than other developed economies: the reduction in hours worked stopped, and life expectancy started to increase at a slower pace despite a surge in health expenditure as a share of GDP. There are many specific explanations for each phenomenon. For example, Case and Deaton (2015) put into the spotlight the opioid epidemic increasing mortality among white non-Hispanic Americans. We investigate the plausibility of a global link between these three phenomena. For some reasons (taxes, change in preferences, change in returns, increasing inequality), Americans are willing to work a lot, thereby deteriorating their health capital at a higher rate than Europeans. They offset their health problems by purchasing costly drugs and medical care, but because curative medicine is less efficient than a preventive life-style, the medical treatment may not be fully operative. As a result, Americans experience lower gains in life expectancy and a higher share of medical spending. We build an exogenous growth model with a dynamic equation of accumulation of health capital (Grossman 1972), which depreciation rate increases with work effort. We are able to reproduce the three stylized facts at the steady state: lower preferences for leisure as in the US lead to both a higher number of hours worked and a higher share of health expenditure and, provided that medical technology exhibits strong enough diminishing returns, a deterioration of the health capital stock which translates into a lower life expectancy. This provides a restriction to test the external validity of our global explanation.

JEL Classification: I1, J22, O41

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1   Introduction

If the US remains the largest and most developed economy in the world as well as the leader in new technologies, the American development model seems to present some weaknesses. A first one is the growing inequality the country has experienced as documented by many authors (Piketty and Saez, Autor). Another one is that the US is losing ground with its international partners in terms of life expectancy gains: indeed, American life expectancy started increasing at a slower pace in the 1980s, resulting in an ever growing gap today. The US health disadvantage has recently been documented and put in international perspective in a comprehensive report by the National Research Council and Institute of Medicine (2013). The panel noted that the United States, despite spending much more money on health care than any other developed country, has seen its relative standing in the world fallen for the last forty years. It was ranked 16th in 1960 in terms of life expectancy for male and females combined but fell steadily down to the 36th rank in 2015. Today, Americans die sooner and experience more illnesses than Europeans. What is even more surprising is that this gap in life expectancy between the US and Western Europe has been growing despite a surge in medical expenditure in the US. Indeed, although health care spending in the US and Europe were quite similar at the beginning of the 1980s (around 7% of GDP for Europe, 8% for the US), Americans now devote more than 16% of their GDP on medical consumption, compared to roughly 11% on average for Western Europe.

In this paper, we offer a global explanation of these two facts that relies on a third well-documented trend: Americans have been working much more than Europeans for quite some time now. At the beginning of the 1980s, Americans and Europeans worked approximately the same number of hours., but today Americans work about as much as they did in the 1980s while Europeans work substantially less. We investigate a possible link between these three phenomena, and we do so by introducing health capital à la Grossman in an exogenous growth model with elastic labor supply. Health is therefore viewed as a stock that can be increased via medical investment (usually the consumption of medical commodities), but that depreciates over time. Our crucial assumption is that the rate of depreciation of health capital is a positive function of individual labor supply. The fraction of time individuals spend on producing goods can therefore be interpreted as the utilization rate of their health stock, as in Greenwood, Hercowitz & Huffman (1988). Focusing on long-run equilibrium, we show that lower preferences for leisure that make individuals work more also lead to a higher share of GDP devoted to health care. This share of medical expenditure increases to offset the extra-depreciation of health capital brought on by a higher number of hours

worked. The effect on the long run capital stock is ambiguous and depends essentially on the efficiency of the medical technology through which individuals make health investments. We show that there is a value of the returns to medical technology lying between 0 and 1 below which a higher number of hours worked leads to a deterioration of the steady state health capital stock.

Our growth model relies on the assumption that to some extent, work is bad for health. The potential impact of differences in hours worked on populations' health has been overlooked despite vast empirical evidence that working hours may have a detrimental impact on one's health. This evidence stems from various disciplines such as biomedical sciences and public health. Sparks et al (1997) conduct a meta-analysis of the literature on the length of the work-week and various health symptoms and find small, but significant positive mean correlations between physiological and psychological health symptoms and hours of work. White and Beswick (2003) focus on the relationship between working hours and fatigue, health and safety, and work-life balance and suggest a positive relationship between working hours and fatigue and cardiovascular disorders, and a negative relationship between hours worked and physical health. In addition to that, strong evidence suggests that people perceive that working long hours leads to poor work-life balance, which might be detrimental to mental health. Bannai and Tamakoshi (2014) provide a survey of the literature on long working hours (more than 40 hours a week, or 8 hours a day) and conclude that such long hours are associated with depressive state, anxiety, poor sleep condition and coronary heart diseases. Furthermore, whereas it is well documented that Americans work longer hours than Europeans, it is much less known that they also work at "strange" hours, that is at night and on week ends (Hamermesh & Stancanelli, 2015), potentially causing more harmful stress. Such evidence gives credit to an idea that has long been in the air: Adam Smith once said that «*mutual emulation and desire for a greater gain prompted them [workers] to over-work themselves, and to hurt their health by excessive labour*» (The Wealth of Nations, 1776). Indeed, the European Working Conditions Survey reveals that around 30% of workers in the European Union think that their health is at risk because of their work, and the share of employees who agree with this statement increases with the number of hours worked.

Furthermore, there is also empirical evidence on the contribution of leisure to good health: Pressman et al (2009) find a general positive relationship between a wide range if leisure activities (some examples are walking or cycling, exercising, sleeping well, going on holidays, engaging in social interactions, or simply having hobbies) and various health benefits, such

as lower blood pressure, waist circumference, body mass index, lower levels of stress and depression, better physical function and mood, better sleep, etc. From an econometric point of view, Sickles and Yazbeck (1998) estimate a production function of health, using both leisure time and medical commodity as inputs, based on US time series data. They find that both inputs make significantly positive contribution to health, and that leisure might actually contribute more than medical consumption.

In addition to that, one important channel through which working might affect health is individual behaviors, such as drinking, smoking or having any kind of physical activity. Using aggregate data to study the effect of economic recessions on alcohol consumption, Ruhm (1995) finds evidence that alcohol consumption actually declines during economic downturns and increases during expansions. Freeman (1999) confirms Ruhm's findings, and Ruhm and Black (2002), using individual-level data, reach the same conclusion that overall drinking is pro-cyclical and suggest that any stress-induced increases in drinking during recessions are more than offset by declines resulting from changes in economic factors such as lower incomes. Ruhm (2005) provides further evidence that changes in lifestyles could be behind improvements in physical health during recessions and shows that smoking and excess weight also decline during short-lasting economic downturns, while physical activity during leisure-time increases. The decline in hours of work increases the non-market time available for lifestyle investments and could be the reason behaviors become healthier.

The outline of the paper is as follows. The first section provides some the empirical evidence for the stylized facts and discuss both alternative and complementary explanations. The second section presents the growth model and solves it at the steady state. The last section concludes and proofs are gathered in the appendix.

2 Stylized Facts

We begin by documenting the diverging patterns between the US and Europe since the 1980s for the three variables we are interested in: life expectancy, health care expenditure and working time. What is striking is that the divergence started approximately at the same time, thus fueling the idea that there might be a causal link between the three stylized facts.

2.1 The American Health Disadvantage

Despite the apparent steady increase in rich countries, the improvement of life expectancy has slowed down in the US starting from 1980, as can be clearly seen in Figure 1. In 1980, average life expectancy at birth in the United States was 77.5 years for women and 70 for men, approximately the same as the average for Western Europe, around 74 years for the whole population. Note that by Western Europe, we consider eight countries that seem comparable to the US: Austria, Belgium, Germany, the Netherlands, Switzerland, France, the UK and Ireland. There has been considerable progress since then and life expectancy at birth for the US population is now 79 years. However, such progress needs to be put in perspective as life expectancy in Western Europe increased much faster and now reaches roughly 82 years. This slow-down of US life expectancy improvement relative to other rich countries is consistent for both men and women, although it is more pronounced for women. The US is losing ground in international rankings for life expectancy: it was ranked 16 in 1960 for male and female combined and fell steadily down to the 36th rank in 2015.
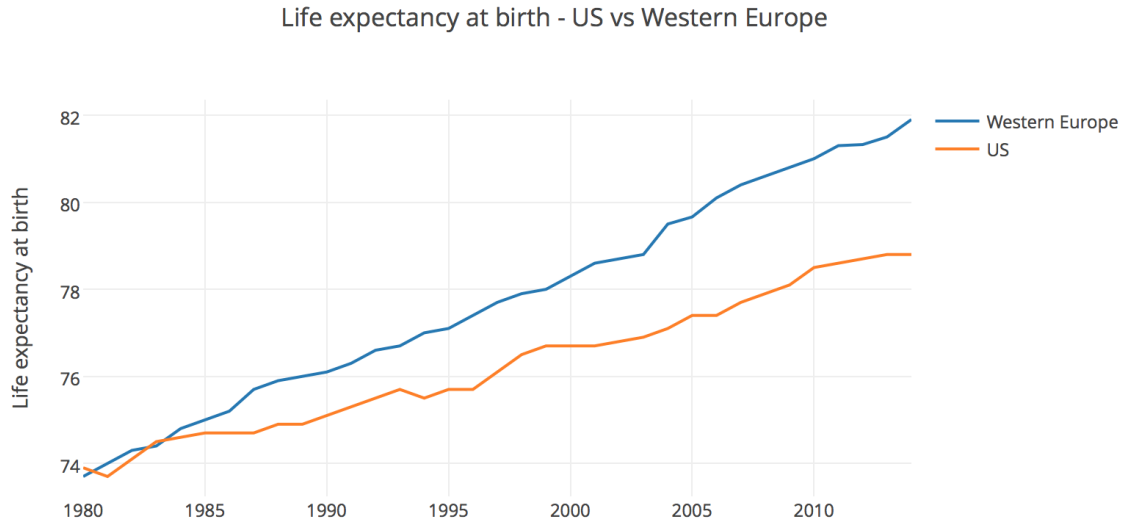

Figure 1. Source: World Bank

Various measures of self-reported health status and biological markers of disease confirm the rough picture painted by aggregate life expectancy. Americans across the socioeconomic distribution report a higher disease burden: 30% higher for lung disease and myocardial infarction, 60% higher for all heart disease and stroke, and twice as high for diabetes (Banks et al, 2006).

Furthermore, the disadvantage is pervasive and affects all groups up to 75 for multiple diseases, biological and behavioral risk factors, and injuries. More specifically, the US fares worse than its counterparts in nine health domains: adverse birth outcomes, injuries and homicides, adolescent pregnancy and STDs, HIV and AIDS, drug-related mortality, obesity and diabetes, heart diseases, chronic lung diseases, disability, and overall, Americans who reach age 50 are in poorer health due to several risk factors such as smoking, obesity, diabetes (National Research Council and Institute of Medicine, 2013).

The first potential explanation that comes to mind is that the surge in inequality observed in the US since the early 1980s was accompanied by an increase in health inequality that drove down the national average. However, it appears that the US health disadvantage relative to peer countries persists even when the US data are limited to non-Hispanic whites or upper-income populations. The disadvantage, although more pronounced among lower socio-economic groups that often lack health insurance, is pervasive and is still present among higher socio-economic groups (Martinson et al, 2011a; Avendano et al., 2009, 2010). Americans who are white, relatively wealthy and insured, are still in poorer health than their Europeans counterparts. Furthermore, despite the lack of access, the US health care system is actually quite performing: it makes use of the most advanced medical techniques and has the highest survival rates for many cancers for example.

2.2 The Rise in Health Expenditure

At the beginning of the 1980s, Americans already devoted a larger fraction of their resources on health care than European, but the difference was of around one percentage point. The gap has been growing ever since and is now close to six percentage points.

There are several potential explanations for the rise in health expenditure in rich countries. On the one hand, focusing on the demand side, are Hall & Jones (2007) who argue that the increase in medical spending that comes along with development is optimal and results from the fact that health is a superior good. They build a model where the marginal utility of consumption diminishes faster than that of life extension, which makes people devote a larger fraction of their income of health care as the economy gets richer. Their model even make the bold prediction that the share of health expenditure in the US could very well reach 30% of GDP by the middle of the century. On the other hand, the supply side explanation relies on technological change: Newhouse (1992) argues that the invention of

new and expensive medical technologies causes health spending to rise. According to Cutler (1995), technology accounts for 49% of the growth in real health care spending per capita between 1940 and 1990. Suen (2005) builds a model where medical innovations that raise the marginal product of medical care in producing health first increases both the duration of life and per-period health expenditure. However, although both explanations justify an increasing share of health spendings along economic development, they fail to account for cross-country differences, and especially for why the US is spending so much more on health care that its Europeans counterparts, for such mixed results.

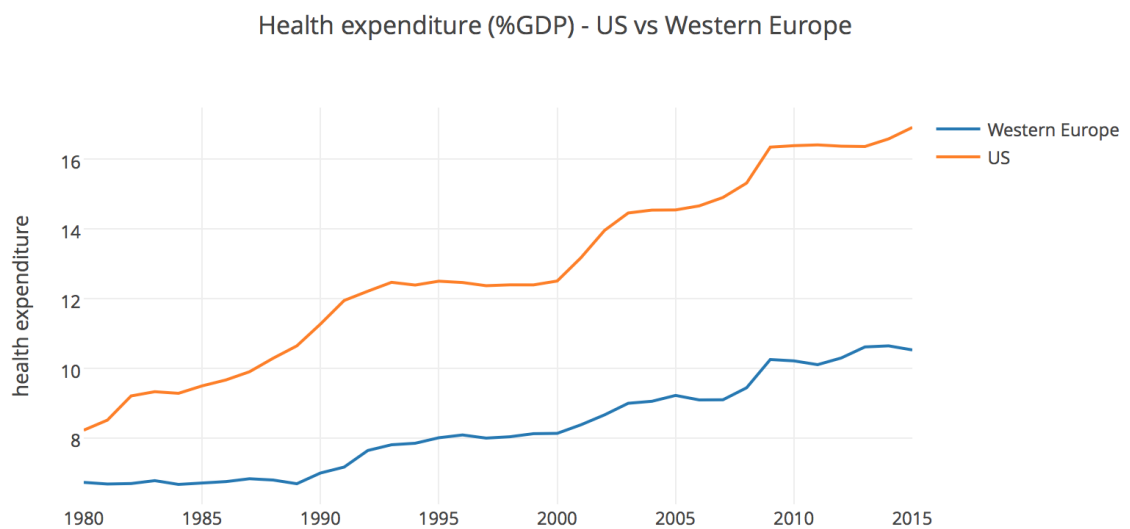Health expenditure (%GDP) - US vs Western Europe

Figure 2. Source: OECD

Another explanation for the growing difference in spending is the difference in the prices of health care goods and services between the US and Europe. He, Huang & Hung (2013) compute the relative price of health care for the US and various European countries, that is, the purchasing power parities-adjusted price indexed of health care goods and services relative to non-medical commodities. They show that the price of health care is 20% higher that that of non-medical consumption in the US, while it is only 4% higher for the European countries considered. The relative price of health care in the US is therefore 16% higher than in Europe. Differences in prices obviously contributes to the growing gap in health care spending but they seem not enough to fully explain the divergence between the US and Europe.

2.3 Americans work more

The United States departed from yet another international trend around the same time. The International Labor Organization's report, *Working Time Around the World*, notes that the twentieth century was characterized by a long process of reduction of working time around the developed world. However, it appears that the US put an halt on this process at the end of the 1970s and the beginning of the 1980s and stopped the collective effort to reduce working time, while European countries continued to do so. Today, Americans work about as much as they did in the 1980s while Europeans work substantially less, as illustrated in Figure 3. Such differences in aggregate hours could come from differences in hours worked per worker, but also from differences in employment rates across countries, or simply from demographics. Blanchard (2004) compares the cases of the US and France and decompose the change in hours worked per capita between 1970 and 2000 into different components: the change in hours worked per worker, the change in the employment rate, the change in the participation rate, and the change in the ratio of the population of working age to total population. It appears the decline in hours worked per capita in France (and by extension, in Western Europe) mostly comes from a decrease in hours worked per worker.
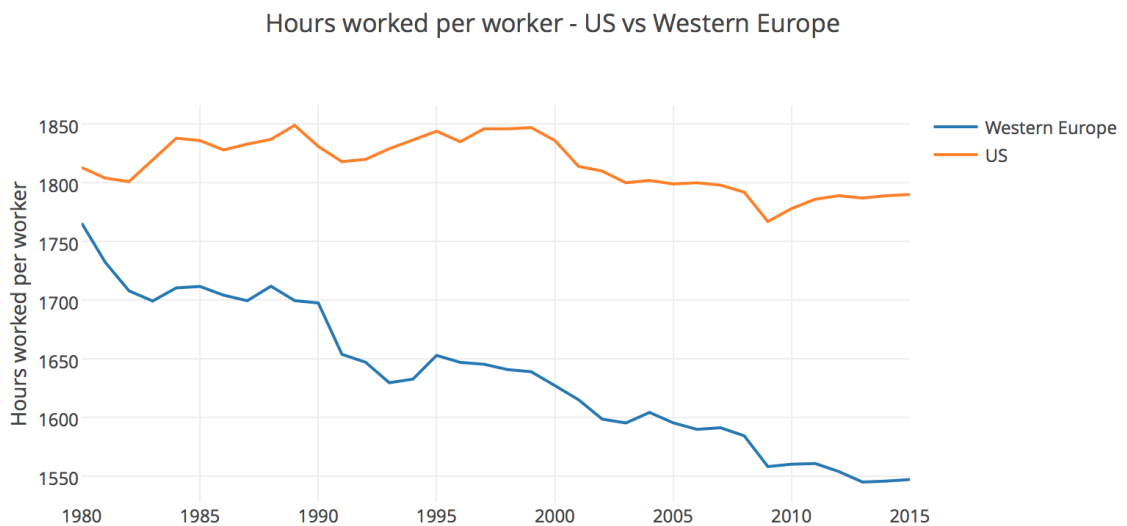

Figure 3. Source: OECD

There is an ongoing debate on the reasons for the divergence of working hours between the US and Western Europe. On the one hand, Prescott (2004) argues that it is all about taxes: higher taxes in Europe lower the opportunity cost of leisure and make agents willing to work less. Differences in taxes between the US and Europe would therefore explain the whole of

the difference in hours worked. However, his analysis has been criticized for relying on unrealistically large values of the micro-elasticity of labour supply. On the other hand, Alesina et al (2005) emphasized the role of trade unions in the reduction of working time in Europe. Furthermore, they argue that large declines of hours worked in unionized sectors may have triggered a reduction in hours worked in other sectors via a social multiplier effect. This idea of a social multiplier is related to the hypothesis that Europeans may have a cultural predilection for leisure. This is argued by Blanchard (2004) who writes that Europeans used productivity gains since the 1980s to increase leisure rather than income, while the US did the opposite. Underlying this argument is an heterogeneity in preferences for leisure across countries, and especially between Western Europe and the US.

This literature has mostly been focused on the implications of the difference in hours worked between the US and Western Europe for income. In the next section, we are exploring the implications of this difference of patterns for health condition.

3   The Model

We assume every households are identical and provide labor services in exchange for wages, receive interest income on assets, purchase goods for consumption and medical care, and save by accumulating assets. For the sake of simplicity, we assume no population growth and normalize the number of individuals to one, such that $N(t) = 1$. This way, aggregate, average and per capita variables are the same. Time is continuous and individuals live forever. Note that in our model, deterioration oh health is captured by a lower stock of health capital rather than a shorter lifespan. We begin by describing the supply side of the economy with firms, before turning to households' behavior.

3.1   Firms

Firms produce the sole final good of the economy that can be either used for consumption, medical care or saved as investment. This implies that the price of medical and non-medical goods and services will be the same, we therefore leave aside differences in health care prices. Let us consider the following simple Cobb-Douglas production function, common to each firm:

$$Y(t) = K(t)^\alpha [l(t)N(t)]^{1-\alpha} \tag{1}$$

Since we normalized population to one and assumed no technological progress, the function can be expressed in per capita terms:

$$y(t) = k(t)^\alpha l(t)^{1-\alpha} \tag{2}$$

Where $l(t)$ is individual labor supply. Let us denote the rental rate of capital as $R(t)$. We assume the capital stock depreciates at the constant rate $\delta > 0$, therefore the net rate of return to an individual that owns a unit of capital is $R(t) - \delta$. Since households can also receive the interest rate $r(t)$ on funds lent to other households, and since both loans and capital are perfect substitutes as stores of values, we have that $r(t) = R(t) - \delta \Leftrightarrow R(t) = r(t) + \delta$. The firm therefore chooses capital and labor inputs, taking $w(t)$ and $r(t)$ as given, to maximize profit:

$$\pi = K(t)^\alpha [l(t)N(t)]^{1-\alpha} - [r(t) + \delta]K(t) - w(t)[l(t)N(t)] \tag{3}$$

The familiar first order conditions arise naturally:

$$r(t) = \alpha k(t)^{\alpha-1} l(t)^{1-\alpha} - \delta \tag{4}$$

$$w(t) = (1-\alpha)k(t)^\alpha l(t)^{-\alpha} \tag{5}$$

3.2   Households

Individuals derive utility from consumption of the final good $c(t)$ and their current health status $h(t)$ which corresponds to their stock of health capital at time t, and derive disutility from individual labor $0 \leq l(t) \leq 1$ they supply each period. We consider a simple period log-utility function with constant marginal disutility of labor of the following form:

$$u[c(t), h(t), l(t)] = \nu \log[c(t)] + (1-\nu)\log[h(t)] - \phi \cdot l(t) \tag{6}$$

where ν is the relative taste for consumption (hence $(1-\nu)$ is the relative taste for health) and ϕ can be interpreted as preferences for leisure. Individuals therefore seek to maximize overall utility U:

$$U = \int_0^\infty u[c(t), h(t), l(t)]e^{-\rho t}dt \tag{7}$$

where $\rho > 0$ is the rate of time preference.

Individuals hold assets which may take the form of ownership claims on capital or as loans.

The two forms of assets are assumed to be perfect substitutes as stores of value so they must pay the same real rate of return $r(t)$. We denote assets per person as $a(t)$. Individuals are competitive and take as given the interest rate $r(t)$ and the wage rate $w(t)$, paid per unit of labor services. The total income received by each individual is therefore the sum of labor income, $w(t)l(t)$, and asset income, $r(t)a(t)$. They use it to consume and purchase medical care $m(t)$, and use the rest to accumulate more assets. The individual budget constraint therefore takes the following form:

$$\dot{a}(t) = w(t)l(t) + r(t)a(t) - c(t) - m(t) \tag{8}$$

We now introduce another type of capital from which agents derive direct utility: health capital. We loosely follow Grossman (1972) who conceptualized the idea that viewed as a stock of capital that can be increased via investment in medical care but which also depreciates along the lifecycle. Our main assumption is that the rate of depreciation of health capital δ_h is a positive function of individual labor supply $l(t)$, or work effort.

$$\dot{h}(t) = m(t)^\sigma - \delta_h[l(t)]h(t) \tag{9}$$

Where σ is the efficiency of health investments and is assumed to be lower than one. Medical expenditure are therefore subject to diminishing returns. We also assume that the relationship between the rate of depreciation of health capital and individual work effort is linear. A convex function would certainly be more realistic as the damage of hours of work on health may become more severe as individuals work more. However, introducing a convex rate of depreciation makes impossible to find an analytical solution to the model and is therefore left for future research. We therefore assume $\delta_h[l(t)] = \gamma \cdot l(t)$ where γ determines how much working is detrimental to one's health.

The households' problem is therefore to choose consumption, medical expenditure and labor supply (three control variables) and assets and health capital (two state variables) to maximize lifetime utility (2), subject to both constraints (3) and (4). We set up the following present-value Hamiltonian:

$$\mathcal{H} = u[c(t), h(t), l(t)]e^{-\rho t} + \lambda(t)[w(t)l(t) + r(t)a(t) - c(t) - m(t)] + \mu(t)[m(t)^\sigma - \gamma l(t)h(t)] \tag{10}$$

The first-order conditions are as follow:

$$\frac{\partial \mathcal{H}}{\partial c(t)} = 0 \quad \Leftrightarrow \quad u_c(.)e^{-\rho t} = \lambda(t) \tag{11}$$

$$\frac{\partial \mathcal{H}}{\partial m(t)} = 0 \quad \Leftrightarrow \quad \sigma m(t)^{\sigma-1}\mu(t) = \lambda(t) \tag{12}$$

$$\frac{\partial \mathcal{H}}{\partial l(t)} = 0 \quad \Leftrightarrow \quad -u_l(.)e^{-\rho t} = \lambda(t)w(t) - \mu(t)\gamma h(t) \tag{13}$$

$$\dot{\lambda}(t) = -\frac{\partial \mathcal{H}}{\partial a(t)} \quad \Leftrightarrow \quad \dot{\lambda}(t) = -r(t)\lambda(t) \tag{14}$$

$$\dot{\mu}(t) = -\frac{\partial \mathcal{H}}{\partial h(t)} \quad \Leftrightarrow \quad \dot{\mu}(t) = -u_h(.)e^{-\rho t} + \mu(t)\gamma l(t) \tag{15}$$

Since there are two state variables, $a(t)$ and $h(t)$, there are two additional transversality conditions:

$$\lim_{t\to\infty}[\lambda(t)a(t)] = 0 \tag{16}$$

$$\lim_{t\to\infty}[\mu(t)h(t)] = 0 \tag{17}$$

Equations (6) and (9) combined yields the familiar Euler equation:

$$\frac{\dot{c(t)}}{c(t)} = r(t) - \rho \tag{18}$$

which tells us individuals are willing to postpone consumption from the present to the future if and only if the real interest rate is greater than the rate of time discount.

Equation (8) characterizes the labor-leisure choice: individuals must be indifferent between one unit additional unit of leisure or work. The left-hand side is the marginal utility of leisure and must be equal to the marginal utility brought by an additional unit of work on the right hand side. The net gains from an additional unit of work is the extra earnings one gets minus the greater depreciation induced on health. Using equations (6) and (7) to get rid of both shadow prices $\mu(t)$ and $\lambda(t)$, we get:

$$-\frac{u_l(t)}{u_c(t)} = w(t) - \left(\frac{\gamma}{\sigma}\right)m(t)^{1-\sigma}h(t) \tag{19}$$

where the left hand side is now the marginal rate of substitution between leisure and consumption, or how much one values leisure in terms of consumption. In standard models, it is just equal to the wage rate $w(t)$, but here since individual labor supply has a negative effect on one's health, the extra depreciation brought by an additional unit of labor lowers the net benefits of working.

Equation (7) indicates that households equate the marginal benefit of medical expenditure $m(t)$ to the shadow price of capital. This marginal benefit is the marginal product of medical expenditure in health investment times the shadow price of health capital $\mu(t)$ and is subject to diminishing returns. Differentiating with respect to time and using equation (9), we obtain:

$$\frac{\dot{m}(t)}{m(t)} = \frac{1}{1-\sigma}\left[r(t) + \frac{\dot{\mu}(t)}{\mu(t)}\right] \tag{20}$$

Now using equation (10) to substitute for $\frac{\dot{\mu}(t)}{\mu(t)}$, we get:

$$\frac{\dot{m}(t)}{m(t)} = \frac{1}{1-\sigma}\left[r(t) + \gamma l(t) - \sigma m(t)^{\sigma-1}\frac{u_h(t)}{u_c(t)}\right] \tag{21}$$

where $\frac{u_h(.)}{u_c(.)}$ is the marginal rate of substitution between health and consumption, or the value of an additional unit of health in terms of consumption. The growth rate of medical expenditure therefore increases with the real interest rate because individuals it makes individuals better off if they save one dollar to spend it on health care tomorrow. The opportunity cost of purchasing health care today increases with the real interest rate. The depreciation rate of health capital $\gamma l(t)$ also increases the growth rate of medical expenditure because the fraction of health capital that depreciates will have to be offset next period. Finally, the growth rate of health expenditure decreases with the value of an additional dollar spent on health care because the higher this value, the more willing are individuals to make the investment in the present period.

The transversality condition for assets arises naturally from the equilibrium conditions. Take the differential equation (9) and integrate to get:

$$\lambda(t) = \lambda(0)\exp\left(-\int_0^t r(v)dv\right) \tag{22}$$

And plugging that back into (11) yields:

$$\lim_{t\to\infty}\left[a(t)\exp\left(-\int_0^t r(v)dv\right)\right] = 0 \tag{23}$$

3.3 Equilibrium

We can now combine the behavior of households and firms who make optimizing choices taking the real interest rate $r(t)$ and the wage rate $w(t)$ as given to study the competitive market equilibrium. First, note that the economy is closed so all debts must cancel at each

period and assets per person $a(t)$ are just equal to the capital stock per worker $k(t)$. Now, if we take households' budget constraint (3), replace $a(t)$ by $k(t)$ and substitute for the values of $r(t)$ and $w(t)$ given by equations (22) and (23), we obtain the resource constraint of the economy:

$$\dot{k(t)} = y(t) - c(t) - m(t) - \delta k(t) \tag{24}$$

This, together with households' optimization conditions (the Euler equation (13), the health capital accumulation equation (4), the equation for medical expenditure (15) and the trade-off between leisure and consumption (16) plus the two transversality conditions (11) and (12), the firms' first order conditions (22) and (23) and market clearing conditions characterize the economy's equilibrium.

3.4 Steady State

We now turn to the existence of a steady state: a particular solution of the equilibrium where labor supply $l(t)$ is constant and the other variables of the economy grow at a constant rate (possibly zero, especially in the absence of technological progress). First, let us denote by $g_i^\star$ the steady state growth rate of variable i. Taking the Euler equation (13) and differentiating with respect to time while assuming that $g_c^\star = (\dot{c}/c)^\star$ is constant, we see that the real interest rate $r^\star$ must also be constant at the steady state. Looking at the first order condition for the firms, this yields $g_k^\star = g_l^\star$. Since at the steady state, labor supply is constant, this means that $g_k^\star = g_l^\star = 0$. Now, differentiate the health capital accumulation equation with respect to time while assuming $\dot{h}/h$ is constant at the steady state to get $g_h^\star = \sigma g_m^\star$. Now do the same with equation (15) for medical expenditure and substitute for the previous result to get $g_c^\star = g_m^\star$. Finally, differentiate equation (16) describing the trade off between leisure and consumption and make again use of the previous results to obtain:

$$\frac{\phi}{\nu} c^\star g_c^\star = -\frac{\gamma}{\sigma} h^\star (m^\star)^{1-\sigma} g_c^\star \tag{25}$$

Since $\frac{\phi}{\nu} c^\star \neq -\frac{\gamma}{\sigma} h^\star (m^\star)^{1-\sigma}$ from equation (16) unless the wage rate $w^\star$ is null, a possibility we rule out, we get that the only steady state that exists is characterized by:

$$g_y^\star = g_k^\star = g_h^\star = g_c^\star = g_m^\star = g_l^\star = 0 \tag{26}$$

Therefore, the steady state solution can be found by setting $\dot{k} = \dot{c} = \dot{m} = \dot{h} = 0$. This together with the leisure-consumption trade off gives us the following system of five equations

and five unknowns that is easily solvable:

$$\dot{k} = k^\alpha l^{1-\alpha} - c - m - \delta k = 0 \tag{27}$$

$$\dot{h} = m - \gamma l \cdot h = 0 \tag{28}$$

$$\dot{c} = \alpha k^{\alpha-1} l^{1-\alpha} - \delta - \rho = 0 \tag{29}$$

$$\dot{m} = \frac{1}{1-\sigma}\left[\alpha k^{\alpha-1} l^{1-\alpha} - \delta + \gamma l(t) - \sigma m(t)^{\sigma-1}\left(\frac{1-\nu}{\nu}\right)\left(\frac{c}{h}\right)\right] m = 0 \tag{30}$$

$$\frac{\phi}{\nu} c = (1-\alpha) k^\alpha l^{-\alpha} - \left(\frac{\gamma}{\sigma}\right) m^{1-\sigma} h \tag{31}$$

First, the Euler equation gives us the steady state (per capita) capital-to-labor ratio:

$$\left(\frac{k}{l}\right)^\star = \left(\frac{\alpha}{\delta+\rho}\right)^{\frac{1}{1-\alpha}} \tag{32}$$

This gives us output as a function of labor supply at the steady state:

$$y^\star = \left(\frac{\alpha}{\delta+\rho}\right)^{\frac{\alpha}{1-\alpha}} l^\star \tag{33}$$

Plus the capital-to-labor ratio in the capital accumulation equation to get:

$$\left(\frac{\alpha}{\delta+\rho}\right)^{\frac{\alpha}{1-\alpha}}\left[\frac{(1-\alpha)\delta+\rho}{\delta+\rho}\right] l^\star = c^\star + m^\star \tag{34}$$

Turning to equation (30) and substituting for $r^\star$:

$$\sigma\left(\frac{1-\nu}{\nu}\right)\left(\frac{c}{h}\right)^\star (m^\star)^{\sigma-1} = \rho + \gamma l^\star \tag{35}$$

Substituting for the steady state health capital stock $h^\star = (m^\star)^\sigma/(\gamma l^\star)$ yields:

$$\left(\frac{c}{m}\right)^\star = \frac{1}{\sigma}\left(\frac{\nu}{1-\nu}\right)\left[1 + \frac{\rho}{\gamma l^\star}\right] \tag{36}$$

This equation tells us that the consumption to medical expenditure ratio is a decreasing function of labor supply at the steady state: the more agents work, the larger fraction of their resources they devote to health care. Now, we can use (35) and (33) to get expressions for consumption and medical expenditure in terms of labor supply:

$$c^\star = \left[\frac{(1-\alpha)\delta+\rho}{\rho+\delta}\left(\frac{\alpha}{\delta+\rho}\right)^{\frac{\alpha}{1-\alpha}}\right]\frac{\nu(\gamma l^\star + \rho)l^\star}{\gamma[\sigma(1-\nu)+\nu]l^\star + \nu\rho} \tag{37}$$

$$m^\star = \left[\frac{(1-\alpha)\delta+\rho}{\rho+\delta}\left(\frac{\alpha}{\delta+\rho}\right)^{\frac{\alpha}{1-\alpha}}\right]\frac{\sigma(1-\nu)\gamma(l^\star)^2}{\gamma[\sigma(1-\nu)+\nu]l^\star + \nu\rho} \tag{38}$$

15

Now that we have an expression for medical expenditure as a function of labor supply, we can express the steady state health capital stock as follows:

$$h^\star = \frac{1}{\gamma}\left[\frac{(1-\alpha)\delta+\rho}{\rho+\delta}\left(\frac{\alpha}{\delta+\rho}\right)^{\frac{\alpha}{1-\alpha}}\right]^\sigma \left[\frac{(1-\nu)}{\gamma l^\star + \nu\rho}\right]^\sigma (l^\star)^{2\sigma-1} \tag{39}$$

Finally, the last variable we are interested in is the share of income that is devoted to health care expenditure:

$$\left(\frac{m}{y}\right)^\star = \left[\frac{(1-\alpha)\delta+\rho}{\rho+\delta}\left(\frac{\alpha}{\delta+\rho}\right)^{\frac{\alpha}{1-\alpha}}\right]\frac{\sigma(1-\nu)\gamma l^\star}{\gamma[\sigma(1-\nu)+\nu]l^\star+\nu\rho} \tag{40}$$

We now have the full solution expressed in terms of individual labor supply. It will be useful in the next sub-section as we intend to see how differences in hours worked affect a country's health capital stock and health expenditure. We can now plug the values of $c^\star$ and $m^\star$ given by equations (37) and (38) into equation (31) to solve for $l^\star$. This gives us the following second order polynomial:

$$\phi(l^\star)^2 + \left[1-\nu-\chi[\sigma(1-\nu)+\nu]+\phi\frac{\rho}{\gamma}\right]l^\star - \nu\chi\frac{\rho}{\gamma} = 0 \tag{41}$$

where $\chi = \frac{(1-\alpha)(\delta+\rho)}{(1-\alpha)\delta+\rho} < 1$. This polynomial gives a unique positive root (see proof in the Appendix):

$$l^\star = \frac{-\left[1-\nu-\chi[\sigma(1-\nu)+\nu]+\phi\frac{\rho}{\gamma}\right]+\sqrt{\left[1-\nu-\chi[\sigma(1-\nu)+\nu]+\phi\frac{\rho}{\gamma}\right]^2+4\phi\nu\chi\frac{\rho}{\gamma}}}{2\phi} \tag{42}$$

The model is therefore full solved and we can now conduct analyses of the steady state.

3.5 Comparative Statics

The aim of this paper is to study how the steady state health capital stock and the share of health care expenditure vary with labor supply. Previously, we argued that differences in hours worked across countries might be the result of differences in preferences for leisure. We therefore study how preferences for leisure affect individuals' labor supply decision, and we then investigate the effects of differences in hours worked on the steady state health capital stock and share of medical expenditure.

3.5.1 Labor Supply

The issue we want to address is the following: how do two identical economies with various preferences vis-à-vis leisure will differ? As can be seen from the analytical expressions of

the different variables of the model, preferences for leisure ϕ appear directly in that of labor supply only, and indirectly in those of other variables through labor supply. We therefore investigate how labor supply varies with such preferences and we then study how the resulting differences in labor supply will affect the whole economy.

Proposition 1 *Lower preferences for leisure lead to a higher number of hours worked.*

We can then turn to the other variables of interest, namely the steady state health capital stock and the share of GDP devoted to health care.

3.5.2 Medical Expenditure as a Share of GDP

Turning to the fraction of total resources that are devoted to health care, we immediately see from equation (40) that this share is a function of preferences for leisure solely from labor supply. How does this share vary with labor supply then?

$$\frac{\partial (m/y)^\star}{\partial l^\star} = \left[\frac{(1-\alpha)\delta + \rho}{\rho + \delta} \left(\frac{\alpha}{\delta + \rho} \right)^{\frac{\alpha}{1-\alpha}} \right] \frac{\sigma(1-\nu)\gamma\nu\rho}{(\gamma[\sigma(1-\nu)+\nu]l^\star + \nu\rho)^2} > 0 \qquad (43)$$

Proposition 2 *Medical expenditure as a share of GDP increases with the number of hours worked.*

Any additional hours of work (and hence any additional unit of labor income an agent gets) can be used to increase both consumption and medical spending, but also increases the rate of depreciation of the health capital stock. A higher number of hours worked therefore raises the opportunity cost of health investments, and households' optimization implies that the marginal rate of substitution of health capital in terms of consumption should also increase: household should shift increase their consumption relative to their health. However, at the steady state, health capital stock is directly negatively affected by a higher work effort, which increases the marginal utility of health capital and hence gives incentives to agents to increase their medical investment. In other words, individuals use the proceeds of their extra labor income to increase both consumption and health care expenditure, but because they have to offset the extra depreciation of their health capital, they increase medical spending more than consumption.

3.5.3 Health Capital Stock

We now turn to analyzing the response of the health capital stock following a change in individual labor supply.

$$\frac{\partial h^\star}{\partial l^\star} = \frac{1}{\gamma} \left[(1-\nu) \frac{(1-\alpha)\delta + \rho}{\rho + \delta} \left(\frac{\alpha}{\delta + \rho} \right)^{\frac{\alpha}{1-\alpha}} \right]^\sigma \left[\frac{(\sigma - 1)\gamma l^\star + (2\sigma - 1)\nu\rho}{(\gamma l^\star + \nu\rho)^3} \right] (l^\star)^{2\sigma - 2} \quad (44)$$

The sign of this derivative is ambiguous. Specifically, the sign of the derivative is just the sign of $(\sigma - 1)\gamma l^\star + (2\sigma - 1)\nu\rho$. We immediately see that when σ is equal to one, the derivative is strictly positive: under constant returns to scale in health investments, the steady state health capital stock increases with the number of hours worked. This is because the medical technology is efficient enough to offset the extra-depreciation induced by an increased work effort. On the other hand, when σ is equal to zero, the derivative is strictly negative because one cannot repair his health capital that depreciated by working. Given that the function $f(\sigma) = (\sigma - 1)\gamma l^\star + (2\sigma - 1)\nu\rho$ is strictly increasing, there exists a unique value of σ, let us call it $\sigma^\star$ for which the derivative of the health capital stock with respect to labor supply is equal to zero, and this threshold value lies between zero and one.

Proposition 3 *There exists a unique value $0 < \sigma^\star < 1$ below which the steady state health capital stock decreases with the number of hours worked.*

In other words, a higher number of hours worked can result in a lower steady state health capital stock, provided that the returns to scale in health investment are low enough.

4   Conclusion

In this paper, we document three distinct trends that have been occurring at a macro level: the slowdown of improvements in American life expectancy, the surge in medical expenditure and the halt that was put to the reduction of working time. Comparing those three trends with what happened in Europe during the same period, we clearly see the US as an exception among rich countries, and the divergence that started in the 1980s resulted in different steady states today. Those trends have been studied separately quite intensively, but we try to draw some causal links between them. Our theory is that differences in preferences that make Americans willing to work more are actually harmful for workers' health. Workers therefore use their extra income to purchase goods as well as medical care, but since their higher labor supply depreciates their health capital stock, they devote a larger fraction of their income to health care to offset the extra depreciation. Provided the medical technology available to them is not efficient enough, the surge in medical expenditure may not be sufficient to

repair the health capital stock, which results in a lower life expectancy for American workers.

There are of course many potential and competing explanations to the American health disadvantage, but none seems able to fully account for the gap between the US and its rich counterparts today. The answer is probably a combination of several factors: increasing inequalities in the US, racial and ethnic disparities, deficiencies within the health care system, inflation of medical goods and services, etc. In the recent years, mortality of middle-aged non-Hispanic whites has even increased, as documented by Case and Deaton (2015), probably because of an increased consumption of opioid among the "white working class". We provide yet another theory to shed light on a mechanism that has not been as investigated as others, the fact that a pressured work schedule might be detrimental to one's physical as well as mental health. This negative effect of long work hours on health probably add up to the existing explanations of the American health disadvantage. Our theory predicts that there is a threshold value for the returns to medical investment below which American life expectancy would be lower as a consequence of a higher number of hours work. This provides a possible empirical test to verify the validity of the model.

There is still no consensus on the reasons why hours worked per worker in the US are much higher than in Europe today. If Prescott argues that higher taxes in Europe can fully account for the hours differential, Blanchard and Alesina among others criticize the results for relying on too strong estimate of the elasticity of labor supply. Blanchard argues that the question to be addressed is that of *"how much of this change comes from preferences and increasing income and how much comes from increasing tax distortion"* (Blanchard, 2004). He claims that the data suggests a greater role for preferences. Bargain et al (2011) analyze the role of preferences heterogeneity in welfare comparisons of rich countries and especially the role of preferences for leisure. Their findings, which control for country-specific consumption-leisure preferences, tend to support the view that cultural differences play an important role.

One distinctive feature of our model is that there are no externalities whatsoever. As a consequence, every decision taken by agents is optimal and so would be the worse health status of American workers despite higher medical spending. We therefore cannot say much about welfare, which is a potential shortcoming of our analysis. A natural extension that comes to mind is to add externalities or bounded rationality. For example, agents might not be able to internalize the negative effect long work hours might have on their health capital and as a result, they would probably overwork and waste resources on health care

that could have been avoided with more leisure time. This could allow us to study the effect government intervention, especially though the implementation of laws that put an upper limit on working hours, as with the Aubry Law in France.

In this paper, we focus on the long run equilibrium only: the steady states rich economies are thought to have gotten to. We therefore compare economies that started with different but constant preferences overtime. The next step to take this research further is to study the dynamics of such a model and the transition path towards a new steady state of an economy that would experience a change in preferences.

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Proofs

Proof of positive labor supply:

The polynomial for labor supply gives us two roots: $l_1^\star = \frac{-b+\sqrt{b^2-4ac}}{2a}$ and $l_2^\star = \frac{-b-\sqrt{b^2-4ac}}{2a}$, where $b = \left[1 - \nu - \chi[\sigma(1-\nu)+\nu] + \phi\frac{\rho}{\gamma}\right]$, $a = \phi > 0$ and $c = -\nu\chi\frac{\rho}{\gamma} < 0$.

Because $a > 0$ and $c < 0$, the determinant $b^2 - 4ac$ is strictly positive, and $l_1^\star$ and $l_2^\star$ are of the sign of $-b+\sqrt{b^2-4ac}$ and $-b-\sqrt{b^2-4ac}$ respectively.

Consider the case where $b > 0$: because $a > 0$ and $c < 0$ once again, it is obvious that $b^2 < b^2 - 4ac$ and hence $b < \sqrt{b^2 - 4ac}$. The root $l_1^\star$ is therefore positive. It is trivial to see that $l_2^\star$ is strictly negative.

Consider the case where $b < 0$: it is again trivial to see that $l_1^\star$ is strictly positive. As for $l_2^\star$, it is positive if and only if $-b - \sqrt{b^2 - 4ac} > 0$ which is true if and only if $-4ac < 0$, which is impossible.

Hence, there is only one root that is always strictly positive, whatever the values of the underlying parameters, and this root is $l_1^\star = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$. **QED**.

Proof of proposition 1:

The derivative of $l^\star = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$ with respect to ϕ is of the form:

$$\frac{\partial l^\star}{\partial \phi} = \frac{u_\phi v - u v_\phi}{v^2}$$

where $u = -b + \sqrt{b^2 - 4ac} > 0$, hence $u_\phi = -b_\phi + \frac{2b_\phi \cdot b - 4a_\phi c}{2\sqrt{b^2 - 4ac}}$ and $v = 2a$, hence $v_\phi = 2a_\phi = 2$.

We want to prove that $\frac{\partial l^\star}{\partial \phi} < 0$ so that labor supply decreases with preferences for leisure. After some algebra and substitutions, we get:

$$\frac{\partial l^\star}{\partial \phi} < 0 \Leftrightarrow [ab_\phi - b][b - \sqrt{b^2 - 4ac}] < -2ac$$

A sufficient condition for this to hold is: $[ab_\phi - b] > 0$, which is always true as long as $\frac{1-\nu}{\nu} > \frac{\chi}{1-\sigma\chi}$. **QED**.

Proof of proposition 3:

We study the sign of the following derivative:

$$\frac{\partial h^\star}{\partial l^\star} = \frac{1}{\gamma} \left[(1-\nu)\frac{(1-\alpha)\delta + \rho}{\rho + \delta} \left(\frac{\alpha}{\delta + \rho} \right)^{\frac{\alpha}{1-\alpha}} \right]^\sigma \left[\frac{(\sigma - 1)\gamma l^\star + (2\sigma - 1)\nu\rho}{(\gamma l^\star + \nu\rho)^3} \right] (l^\star)^{2\sigma - 2}$$

It is trivial to see the sign of $\frac{\partial h^\star}{\partial l^\star}$ is the sign of the function $f(\sigma) = (\sigma - 1)\gamma l^\star(\sigma) + (2\sigma - 1)\nu\rho$.

We want to show that for $\sigma \in [0, 1]$, the derivative can be negative as well as positive.

$$f(0) = -(\gamma l^\star(0) + \nu\rho) < 0 \quad \& \quad f(1) = \nu\rho > 0$$

Given that the function $f(\sigma)$ is strictly increasing for $\sigma \in [0,1]$, we conclude that there exists a unique value $\sigma^\star$ below which $\frac{\partial h^\star}{\partial l^\star} < 0$ and above which $\frac{\partial h^\star}{\partial l^\star} > 0$. **QED**.