Substituting Leisure for Health Expenditure: A General Equilibrium-Based Empirical Investigation

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Abstract

We develop a general equilibrium macroeconomic model with endogenous health accumulation, and use the model's equilibrium condition to estimate the elasticity of substitution between medical care and leisure time in maintaining health based on a cross-country panel dataset. Our econometric estimates imply that increasing health-enhancing leisure time can substantially reduce national health expenditure, and thus may also help resolve the pressing fiscal uncertainty. Our study highlights the importance of several current national inititatives, such as "Let's Move!", from not only health but macroeconomic perspectives. Our study also provides a guidance to a growing literature on macro-health in modelling health production.

JEL classifications: E2, E6, I1

Keywords: general equilibrium, macro-health, health care, leisure time, elasticity of substitution, fiscal uncertainty

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1 Introduction

The importance of health for social welfare has gained an increasing attention in the recent economics literature (e.g., Murphy and Topel 2006, Hall and Jones 2007, Jones and Klenow 2011). As important as it gets, life expectancy of total population at birth, a widely used measure for national health status, is lower in the US than in most other OECD countries. For instance, in 2010, it was 78.7 years in the US, compared to 83.0 years in Japan, 82.2 years in Spain, 81.3 years in France, 80.6 years in the UK, 80.5 years in Germany, 80.3 years in Belgium, 79.5 years in Slovenia, and 79.0 years in Chile.[1] This has motivated several national campaigns in the US, aimed at enhancing national health status.

The relatively low health status of Americans looks even more troublesome when viewed in light of the fact that health expenditure is much higher in the US than in the other countries. In 2010, for example, health expenditure-GDP ratio was 17.6% while health expenditure per capita was \$8362 (PPP, constant 2005 \$) in the US, compared to 8.0% and \$1199 in Chile, 9.0% and \$2552 in Slovenia, 9.5% and \$3204 in Japan, 9.6% and \$3027 in Spain, 9.6% and \$3480 in UK, 10.5% and \$4025 in Belgium, 11.6% and \$4021 in France, and 11.6% and \$4332 in Germany.[2] National health expenditure in the US has actually been on an upward trend, which shows no signs of slowing down. This is illustrated in Figure 1.[3] Were this trend to continue, US health expenditure would take up about 26% of its GDP in 2037, as projected by Congressional Budget Office (CBO 2012). This seemly nonstopping

[1] Data of life expectancy are taken from Organisation for Economic Co-operation and Development (hereafter OECD) Health Data 2012. URL: http://stats.oecd.org/Index.aspx?DataSetCode=SHA.

[2] Data of health expenditure-GDP ratio are taken from OECD Health Data 2012. The data of Japan is for 2009. URL: http://stats.oecd.org/Index.aspx?DataSetCode=SHA. Data of health expenditure per capita (PPP) are taken from World Bank World Development Indicators (WDI). URL: http://databank.worldbank.org/.

[3] Data in Figure 1 are extracted from OECD Statistical Databases–OECD.Stat. According to the OECD, total health care expenditure is defined as the sum of expenditures on activities that include personal health care services, medical goods dispensed to out-patients, services of prevention and public health, health administration and health insurance, and investment into medical facilities. Public health expenditure is health expenditure incurred by public funds which include state, regional and local government bodies and social security schemes. Government final consumption expenditure consists of expenditure, including imputed expenditure, incurred by general government on both individual consumption goods and services and collective consumption services. Central government debt (only available for the US from 1980 in OECD.Stat) is the entire stock of direct central government (exclude state and local government) fixed-term contractual obligations to others outstanding on a particular date, usually the last day of the fiscal year. See http://stats.oecd.org/index.aspx for more details.

trend has raised serious concerns nationwide, which took a center stage in health policy debates during the last two presidential campaigns.

The high and rapidly rising health expenditure in fact has a critical implication for another pressing national issue. This has to do with the high and quickly rising public debt in the US. As can be seen from Figure 1, the US Federal government debt-GDP ratio was 25.7% in 1980, and it has since risen dramatically, even with the temporary reversal in the 1990s, climbing up to 61.3% in 2010, and projected to reach 199% by 2037 (CBO 2012). This has stimulated a wide-spread concern among public, policy makers and economic researchers about the sustainability of current fiscal system going forward (e.g., Davig, Leeper, and Walker 2010, Chen and Imrohoroglu 2012, Evans, Kotlikoff and Phillips 2012).

The crucial and relevant fact then is that, the major source of the looming fiscal uncertainty in the US comes from exploding public expenditure on health care. As can be inferred from Figure 1, US public health expenditure has been growing at an even faster pace than private health expenditure, and its share in total health expenditure has increased significantly over the last forty years, from 36.1% in 1970, to 48.2% in 2010, and is still rising. As a result, public health expenditure as a share in government final consumption expenditure has risen at an even more dramatic pace, from 14% in 1970, to 47% in 2010. As Americans spend a greater share of their income on health care, a much greater share of US government spending is devoted to maintaining the nation's public health programs.[4] As a matter of fact, according to the projections by CBO, containing public health expenditure is the only hope to reverse the accelerating path of US government spending, as can be seen from Figure 2.[5] As Alan Blinder puts it:

"If we can somehow solve the health care cost problem, we will also solve the long-run deficit problem. But if we can't control health care costs, the long-run deficit problem is insoluble. Simple, right? Impossible? We'd better hope not."

[4]Nowadays, US government spends much more on health care than on any other single expenditure category, such as Social Security, education, and national defense.

[5]Figure 2 is constructed according to the projections of "Extended Alternative Fiscal Scenario" from *The 2012 Long-Term Budget Outlook*, CBO. All the projections are at US Federal government level. Federal health care spending consists of projected spending on Medicare, Medicaid, the Children's Health Insurance Program (CHIP), and the insurance subsidies that will be provided through the health insurance exchanges that will be established starting in 2014. Total government noninterest spending includes health care spending, Social Security, and other noninterest spending. Total government spending consists of both noninterest and interest spending. The projected Federal government debt-GDP ratio will reach 247% in 2042 and will exceed 250% after that. CBO does not report debt of more than 250% of GDP or projections based on debt above that level, such as interest outlays. Therefore we do not have the projections for government debt and total government spending after 2042.

We argue that increasing health-enhancing leisure time may substantially reduce national health expenditure while maintaining national health status, and thus may also provide a hopeful resolution to the pressing fiscal uncertainty. Our point of departure rises upon the fact, to be documented below, that not only medical expenditure, but also leisure time is an important input in health production, and that the two inputs are fairly substitutable as our econometric estimates demonstrate. We believe that when it comes to health production, health care spending is not the only way to improve our health. Health-enhancing leisure time is also a critical input for producing good health.[6] If leisure is an important input for good health, by encouraging people to spend more health-enhancing leisure time, we might be able to improve the nation's health status.[7] Several national campaigns have already been launched to promote the idea of increasing physical activities and improving public health. The First Lady Michelle Obama launched a comprehensive initiative called "Let's Move!" to end childhood obesity in the US. The campaign would encourage more physical activity for children and healthier food in schools. The National Coalition for Promoting Physical Activity (NCPPA) aims at promoting all sectors of American society working together to improve the public's health and prevent and manage chronic diseases through increased levels of physical activity. NCPPA is taking action to promote Personal Health Investment Today Act (PHIT) which would allow taxpayers to place up to $2,000 a year in existing pre-tax medical accounts for reimbursement of physical activity expenses.

Our study in this paper shares the concern of these national campaigns. However, we ask a deeper question: besides improving public health status, would these national campaigns also achieve the goal of reducing national health expenditure and hence help to relieve some pressure on the fiscal uncertainty? If the answer is yes,

[6] Enormous biomedical and public health literature provide the evidence that health-enhancing leisure time is a critical input for producing good health. For example, Pressman et al. (2009) find that a wide variety of leisure activities are associated with psychosocial and physical measures relevant for health and well-being such as level of stress and depression, blood pressure, total cortisol, waist circumference, and body mass index. This fact has also been supported by empirical economic literature. See Kenkel (1995), Sickles and Yazbeck (1998), Contoyannis and Jones (2004), and Insler (2011), among others.

[7] Comanor et al. (2006) estimate a health production function with both health care and lifestyle which includes smoking, alcohol consumption and obesity rate as two inputs. They find that the relatively poor health outcomes reported from US are mainly driven by a particular risk factor: high obesity rates. Once this factor is accounted for, the position of US as an outlier among other developed countries is reduced. Finkelstein et al. (2003) estimate that 9.1% of total US medical expenditures is due to obesity and/or being overweight. There are several medical studies showing increasing physical activities is an effective way to reduce obesity rate and hence cut down obesity-related medical expenditures (see NHS CRD 1997, NIH 1998).

how much medical expenditure can be saved through increasing leisure activities?

The answer to this question relies crucially on the relationship between leisure time and medical care in health production function. If leisure is complementary to medical care, an increase in health-enhancing leisure time might raise medical expenditure simultaneously. On the other hand, a substitution between leisure time and medical care would imply that these national campaigns might not only improve national health status, but also help to lower down national health expenditure and hence shed light on a possible solution to fiscal unsustainability. Therefore, to what extent we can reconcile these two distinct policy concerns largely depends on what is the relationship between these two primary inputs in health production function.

Although, as we mentioned above, the empirical evidence on the importance of leisure time as an input to improve health status is abundant, the empirical investigation on the relationship between leisure time and medical care in health production is largely ignored in the literature.[8] This paper is the first attempt to fill the void, both theoretically and empirically. To this end, we propose a general equilibrium macroeconomic model with endogenous health accumulation in which we explicitly model leisure time as a primary input in the health production function. Leisure time plays dual roles in health production technology: enhance health and interact with health-related consumption. An core estimation equation is derived from this general equilibrium framework which helps to identify the elasticity of substitution between leisure time and health care. Closely following our theoretical model, we then construct a short panel of cross-country data set to estimate the equation. The data structure helps us to successfully control the individual effects which are quite common in this type of cross-country data estimation. We find that the elasticity of substitution between leisure time and health-related consumption good in health production function is significant. Its mean is around one with a narrow range. Based on this model-based estimation of elasticity, our calculation shows that if Americans on average spend one more hour per day in health-enhancing leisure time such as physical activities as suggested by all these national campaigns, real annual medical expenditure per working age population would have decreased \$1230 and that would have saved 251 billion 2005 US dollars, which accounts for about 10.7% of national health expenditure in 2008. And this number could be tripled if we can encourage more health-enhancing leisure activities out of sedentary lifestyle such as

[8]Some medical studies document the clinical and anecdotal evidence that increases in leisure time physical activities might help reduce medical expenditures among sedentary adults (e.g., Colditz 1999; Pratt, Macera, and Wang 2000; Wang and Brown 2004; Brown, Wang, and Safran 2005). However, none of these work have done a serious econometric analysis on estimating the elasticity of substitution between the two primary inputs in health production function.

"couch potato." Therefore, initiatives such as "Let's Move!" not only improve the nation's health status by reducing obesity rate, but also could significantly lower national health expenditure to "bend the cost curve" and hence contributes to resolve the emergency fiscal uncertainty that this country is facing. These initiatives thus could complement the current health care reforms such as the Patient Protection and Affordable Care Act (PPACA) which mainly targets on extending the number of uninsured by imposing individual and employer mandate. There are evidences showing PPACA, however, isn't very successful in controlling health care cost.[9] Our study shows that by putting not only health expenditure but also leisure time into horizon, we might find an important alternative to PPACA in slowing the seemingly inexorable growth of national health expenditure, let alone these initiatives are far more easy to be implemented and much less politically controversial to be debated.

This paper also contributes to a growing literature which employs a macroeconomic framework to study different aspects of health care system in the US (e.g., Suen 2006, Hall and Jones 2007, Feng 2009, Jung and Tran 2009, Zhao 2010, Halliday, He and Zhang 2012). This macro-health literature often involves a macroeconomic model with endogenous health accumulation of which explicit health production function is a key component. However, researchers have not reached any consensus on what should be an appropriate function form of the health production function. The current paper sheds light on that issue and offers the first empirical investigation on the elasticity of substitution between inputs in health production function.

The remaining of the paper is organized as follows. Section 2 details the theoretical framework which motivates the empirical investigation. Section 3 describes the construction of data. Section 4 presents empirical results. Section 5 summarizes the policy implication of our empirical results. Finally, Section 6 concludes.

2 Theoretical Framework

As mentioned in the introduction, although we have several empirical studies and clinical and anecdotal evidence showing leisure time is an important input in producing health and increases in leisure time physical activities might help reduce medical expenditures, however, none of these work has done a systematic assessment on the relationship between medical care and leisure time in the health production function. The empirical investigation on this relationship not only provides an answer to a question that has strong academic interest, but also has an important policy

[9] See http://blog.heritage.org/2012/06/15/new-report-shows-health-spending-spikes-under-obamacare/.

implication on providing an alternative to the current health care reform in controlling rising national health expenditure. In this section, we lay out a theoretical framework to allow us empirically estimate the relationship between medical care and leisure time in the health production function. For exposition purpose, we present a simple theoretical framework here and delay the discussion of a full-blown general equilibrium model to the appendix. However, we should point out that general equilibrium framework gives rise to the identical core estimation equation as shown in this section.

Motivated by Grossman (1972, 2000) and the empirical evidence presented in the introduction, we assume that the health stock of the representative agent at time t, h_t, is produced by a production function $H(m_t, l_t)$ which uses health-related consumption good (m_t) and leisure time (l_t) as inputs.

An agent decides the optimal allocation of both inputs in health production by solving a problem to minimize the total production cost of health as follows

$$\begin{aligned} & \min_{m_t, l_t} p_t m_t + w_t l_t \\ & s.t. \\ h_t &= H(m_t, l_t) \geq \underline{h} \end{aligned} \tag{1}$$

where p_t denotes the relative price of health-related consumption good (in terms of output in the economy) and w_t denotes the wage rate, which represents the opportunity cost and hence the shadow price of leisure time. Notice that the agent solves the problem taking the factor prices p_t and w_t as given.[10]

The first-order condition for the cost-minimization problem is

$$\frac{\partial H/\partial m_t}{\partial H/\partial l_t} = \frac{p_t}{w_t}. \tag{2}$$

In other words, the agent will optimally choose the allocation of m_t and l_t in health production whenever the marginal rate of technical substitution between leisure and health-related consumption is equal to the relative price ratio of health-related consumption to leisure.

There is few literature on what should be an appropriate functional form of health production function $H(\cdot, \cdot)$. Sickles and Yazbeck (1998) assume a trans-log production function of health, which is a generalization of Cobb-Douglas function.

[10] A dual problem would be to maximize health stock, subject to the total production cost of health has to be below a certain amount. This dual problem of course yields the identical FOC as in equation (2).

To allow flexibility of estimating elasticity of substitution between leisure and health-related consumption in health production function, we assume that H takes the form of constant-elasticity-of-substitution (CES) as follows

$$H(m_t, l_t) = (\theta m_t^{\xi} + (1-\theta) l_t^{\xi})^{\frac{1}{\xi}} \tag{3}$$

where $0 < \theta < 1$ and the elasticity of substitution between m and l is $\frac{1}{1-\xi}$. Given this functional form, first-order condition (2) changes to

$$\left(\frac{m_t}{l_t}\right)^{\xi-1} = \frac{1-\theta}{\theta}\frac{p_t}{w_t}.$$

Taking logarithm on both sides, we have

$$\ln \frac{m_t}{l_t} = \frac{1}{\xi-1} \ln \frac{1-\theta}{\theta} + \frac{1}{\xi-1} \ln \frac{p_t}{w_t}.$$

It can be simplified as the following linear regression equation

$$\ln y_t = \beta_0 + \beta_1 \ln x_t + \upsilon_t \tag{4}$$

where y_t is the ratio of health-related consumption good to leisure time, x_t is the ratio of the relative price of health-related consumption good to wage, and υ_t is the independent and identically distributed error. The elasticity of substitution between health-related consumption good and leisure time is equal to $-\beta_1$.

Notice that some type of leisure activities, such as "couch potato," might not be health-enhancing. Therefore we can further divide total leisure time into health-enhancing leisure time (e.g., exercising, socialing, relaxing), called l_g, and health-neutral leisure time, called l_n. The health production function uses health-related consumption m and health-enhancing leisure time l_g as two inputs. In this case, it is easy to show that the model still provides an estimation equation similar to equation (4), with y_t to be the ratio of health-related consumption good to health-enhancing leisure time. As long as the health-enhancing leisure time accounts for a constant fraction of total leisure time, which is a reasonable assumption, β_1 in equation (4) is still able to measure the elasticity of substitution between health-related consumption and health-enhancing leisure time.

3 Data

We estimate equation (4) using cross-country data. We construct the data closely following the theoretical framework in Section 2. The data come from OECD, World

Bank and Conference Board. Data availability limits our choice of countries and only 35 countries happen to have complete constructed data as we explain as follows. These countries include Australia, Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Malta, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, South Korea, Spain, Sweden, Switzerland, Turkey, UK and US. The data cover two years: 2005 and 2008.

3.1 Measures of relative price of health-related consumption

The measurement of the relative price of health-related consumption p_t comes from OECD data. To facilitate cross-country comparisons of relative price of health care, we rely on the purchasing power parity (PPP)-adjusted price index reported in OECD 2005 and 2008 PPP Benchmark Results.[11] Notice that OECD uses two methods to calculate PPP-based price levels for real expenditure: EKS and GK method. Table 1.11 in the 2005 and 2008 PPP Benchmark Results reports the price levels for expenditure at average OECD price based on EKS method. Table A2 reports the price levels of expenditure based on GK method. The details of two methods can be referred to the OECD Methodological Manual on Purchasing Power Parities.[12] EKS method is considered to be better suited to comparisons across countries of the price and volume levels of individual aggregates. However, since the real final expenditures in EKS method are not additive, it is not suitable for comparing relative price of individual expenditure categories across countries. In contrast, the real final expenditures in GK method is additive. Therefore, GK method is better suited to the analysis of price and volume structures across countries such as the relative price of health-related consumption to output, which is our target. We hence use Table A2 in the OECD PPP Benchmark Results to obtain p_t for $t = 2005$ and 2008. Column 19 in Table A2 reports GK method-based PPP-adjusted price level of health care and column 1 in the same table reports GK method-based PPP-adjusted price level of GDP, which the latter is normalized to 100 for each country. Therefore, use column 1 to divide column 19, we have the data counterpart of relative price of health care p_t.

The second and third column in Table 1 show the relative price of health-related consumption in 35 countries for 2005 and 2008. For example, it shows that the price

[11] OECD PPP Benchmark Results is a widely used dataset for international comparison of relative prices for health care goods and services (e.g., Pearson 2009). The data are downloaded from http://stats.oecd.org/Index.aspx?DataSetCode=PPP2005.

[12] The manual can be downloaded from http://www.oecd.org/std/pricesandpurchasingpowerparitiesppp/37984252.pdf

of health care is 16% higher than that of GDP in the US in 2005. While in Germany it is opposite. Health care is 5% cheaper than the general price level in 2005. This implies that health care is relatively more expensive in the US than Germany, relative in the sense of comparing to the general price level in the economy. Notice that the US has relatively higher medical care price than most of the countries in our data set.

3.2 Measures of health-related consumption

The measurement of health-related consumption good m_t comes from World Bank. Notice that by definition, we have

$$M_t = p_t m_t$$

where M_t represents real medical expenditures at time t. Therefore, we have

$$m_t = \frac{M_t}{p_t}. \tag{5}$$

Motivated by equation (5), we construct health-related consumption good m_t as follows. Since the measurement of p_t is PPP-based, and the health-related consumption good m_t is a quantity measure, the data counterpart of real health expenditure M_t has to be PPP-based as well. World Development Indicators (WDI) from World Bank provides the data of health expenditure per capita, PPP (constant 2005 international \$). It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health. Data are in international dollars converted using 2005 PPP rates. We divide this variable by the share of population ages 15-64 (working age population) in total population (data taken from World Bank WDI) to transfer the data to health expenditure per working age population, PPP (constant 2005 international \$), which is the data counterpart of M_t. We then divide it by the data of p_t shown in Table 1 to obtain the real annual health-related consumption per working age population m_t. The fourth and fifth column in Table 1 show the data of m_t in 2005 and 2008 respectively. It shows that the health-related real consumption, or the *quantity* of health care in the US is about 8035 constant 2005 international \$, while the *quantity* of health care in Germany is much lower at the level of 5292 constant 2005 international \$. Notice that the US has the highest "quantity" of health care in our data set when we control the effect of relative price of health care.

3.3 Measures of wage

Due to the data availability, we do not have the data of annualized wage w_t for 35 countries. We therefore construct them appealing to a standard neoclassical production function which is also used in the general equilibrium theoretical framework in Appendix (see equation 11). Based on this Cobb-Douglas production function, the first-order condition to the profit-maximization problem for the firm yields

$$w_t = (1-\alpha)\frac{g_t}{n_t} \tag{6}$$

where w_t is the wage rate, g_t is the output (GDP) and n_t is the working hours per working age population. Motivated by equation (6), we construct the data of w_t as follows. First, to be consistent with the construction of p_t and m_t, we obtain the data of aggregate GDP, PPP (constant 2005 international \$) from WDI. We then divide them by the working age population data from World Bank to obtain PPP-based real GDP worked per working age population, which is the data counterpart of g_t in equation (6). Second, we obtain total annual hours worked for 35 countries in 2005 and 2008 from Conference Board Total Economy Database (TED). We divide them by the working age population data from World Bank to obtain annual hours worked per working age population n_t.[13] Third, we set labor income share $(1-\alpha) = 0.64$, which is a commonly used value in the literature. We then apply equation (6) to infer the hourly wage. Finally, we multiply the hourly wage by the annual hours worked per working age population obtained in the second step to construct annualized wage. The sixth and seventh column in Table 1 show the data of w_t. We see a significant variation across countries on annualized wage, from the lowest level \$11124 (constant 2005 international \$) in Turkey to the highest level \$65153 in Luxembourg in 2005.

3.4 Measures of leisure time

We construct the measurement of leisure time following the literature (e.g., Rogerson 2006; Ohanian, Raffo, and Rogerson 2008; Jones and Klenow 2011) and also our general equilibrium theoretical framework presented in the Appendix (see equation 12). In every period, time endowment of the representative agent is normalized to be one. The time is devoted to either paid work (n_t) or leisure (l_t) at time t. Motivated by equation (12), we construct the leisure time l_t in 35 countries as follows. First, we construct annual hours worked per working age population as in Section 3.3. We then

[13] The way we construct n_t aims to capture both intensive and extensive margins for cross-country comparison. See Rogerson (2006) and Ohanian, Raffo, and Rogerson (2008).

divide the data by 365×16 to convert it into a fraction of total annual discretionary time. Leisure time l_t is just equal to $1-$ fraction of annual hours worked per working age population. The eighth and ninth column in Table 1 show the data of l_t.[14] Again, we observe a significant variation across countries on the share of leisure time, from the lowest level 73.2% in South Korea to the highest level 85.0% in Turkey in 2005.

Table 2 provides the descriptive statistics of the dependent variable–the ratio of health-related consumption good to leisure time m/l–and the independent variable–the ratio of the relative price of health-related consumption good to wage p/w. We also include several controls, i.e., the share of public health expenditure in total health expenditure (pub), share of individuals aged above 65 in the total population (age65), total population (pop) and life expectancy (life) that are used later in the estimation in the same table.[15]

Table 3 shows the correlation among the variables. They are all in terms of log unit as they will appear in the estimation equation (10) below. Dependant variable $\ln(m/l)$ are highly negatively correlated with our main regressor derived from the theoretical framework–$\ln(p/w)$. This clearly shows that there exists a substitution relationship between health-related consumption and leisure time in health production from the data.

4 Empirical Results

In this section, we show our empirical model and the estimation results.

4.1 Empirical model

The data we constructed above is a panel data. For country i and time t, the simple estimation equation (4) changes to

$$\ln(m/l)_{it} = \beta_0 + \beta_1 \ln(p/w)_{it} + v_{it}. \tag{7}$$

However, this equation might omit some important country-specific variables that could have explanation power on dependant variable. In other words, the term v_{it} can be represented by

$$v_{it} = \delta_i + u_{it} \tag{8}$$

[14] Sickles and Yazbeck (1998) use a similar approach to construct the measure of desired leisure. In their paper, level of leisure is a continuous variable obtained by substracting the number of hours actually worked from total available hours.

[15] The data of all these four varibles are taken from World Bank World Development Indicators (WDI).

where δ_i represent the unobserved country-specific effects or unobserved heterogeneity which capture for example historical, social, and institutional differences among these 35 countries, while u_{it} is the error term. Substituting equation (8) into equation (7), we have the optimization-based benchmark estimation equation:

$$\ln(m/l)_{it} = \beta_0 + \beta_1 \ln(p/w)_{it} + \delta_i + u_{it}. \tag{9}$$

Since we do not have any prior information regarding the correlation between the unobserved individual heterogeneity and independent variable $\ln(p/w)$, either fixed effects (FE) or random effects (RE) could be the appropriate model for the estimation. We have to rely on the necessary tests including F-test for fixed effect, Breusch-Pagan Lagrangian multiplier (LM) test for random effect, and Hausman test to differentiate between FE and RE models for estimating equation (9) as explained in details below.

4.2 Results

First, we treat equation (9) as a fixed effects (FE) model.[16] In other words, we view the country-specific individual effect δ_i, although is unobserved, is correlated to the regressor $\ln(p/w)$. The results of FE estimation of equation (9) are reported in the second column of Table 4. β_1 is -1.3322 and it is significant at 1% level. It shows that for one unit increase in the ratio of relative price of health-related consumption to wage, the ratio of health-related consumption to leisure is expected to decrease by 1.3322 units. That implies the elasticity of substitution between health-related consumption m and leisure time l in health production is 1.3322.[17]

Second, we run RE estimation of equation (9) assuming individual effect δ_i is unobserved and uncorrelated to the independent variable $\ln(p/w)$.[18] The results are reported in the third column of Table 4. In this case, β_1 is -1.3462 and it is again

[16] The F test of equation (9) shows the p-value of 0.001 ($F(34, 34) = 2.922$, $Prob > F = 0.001$) which suggests that the fixed effect presents.

[17] In Table 4, we report the adjusted R^2 from a pooled regression with countries dummies (LSDV model) by using .areg command in Stata as suggested by Park (2009). For the FE model, .xtreg in Stata estimates within-group variation by computing the differences between observed values and their means without creating dummy variables. The parameter estimates are correct. However, since it surppesses the intercept, due to the larger degrees of freedom for error, its standard errors and, consequently, R^2 statistic are incorrect. In contrast, least squares dummy variable model (LSDV) uses dummy variables and hence overcomes the problem and provides correct R^2. See Park (2009) for more details.

[18] We run Breusch and Pagan Lagrangian multiplier (LM) test for random effects to equation (9). With $\chi^2 = 8.40$ and $Prob > \chi^2 = 0.0019$, the test suggests that the individual effect is random.

significant at 1% level. That implies the elasticity of substitution between m and l in health production is 1.3462.[19]

Since F test and Breusch-Pagan Lagrangian multiplier (LM) test suggest that FE and RE both exist, to test which model (FE vs. RE) is more appropriate for the estimation equation (9), we run Hausman Test.[20] With $\chi^2 = 0.00$ and $Prob > \chi^2 = 0.9988$, we accept the null hypothesis that the coefficients estimated by the efficient RE estimator are the same as the ones estimated by the consistent FE estimator. And since RE is more efficient, RE is a more appropriate estimator to use. However, as we notice, the estimated β_1 is very close under RE and FE.

To further check the robustness of our results, we also run maximum likelihood random-effects regression estimation to equation (9), which is an MLE that fully maximizes the likelihood of the RE model. We report the results in the forth column of Table 4. The estimated β_1 is almost identical to that in RE model.

Finally, we perform the bootstrap estimation to the RE model of equation (9).[21] We report the results in the fifth column of Table 4. The estimated β_1 is exactly identical to that in RE model.

In summary, the estimation results of equation (9) are very robust and quite close to each other under different estimation methods. The estimation implies that the elasticity of substitution between health-related consumption m and leisure time l in health production is around 1.35.

4.3 Extended Empirical Model and Results

The theoretical framework we present in Section 2 is a very simple and highly stylized one which we use to derive the core optimization-based estimation equation (9). It hence abstracts away many factors that could possibly affect medical care and/or leisure time which consist of our dependant variable in equation (9). To check whether or not our core estimation equation is sensitive to those abstractions and also further control the individual effects in the empirical model, we consider several alternative estimation equations in which we add four possible variables, separately and jointly, that might affect dependant variable, namely log of the ratio of

[19]For both FE and RE estimation, the bootstrapped and robust standard errors have been checked for possible serial correlation in the error term of equation (9). The estimated β_1 is identical in both cases to the benchmark FE and RE estimation results.

[20]However, we are aware that Hausman test might be subject to a uniformity bias and thus may not be appropriate to test FE against RE. Therefore we decide, for each empirical model, to present both FE and RE results simultaneously. See Guggenberger (2010) for more details about the uniformity bias of Hausman test.

[21]The number of bootstrap replications is set to be 400. Random-number seed is set to be 10101.

health-related consumption to leisure time between 2005 and 2008. As we summarize in Table 2, these four controls are the share of public health expenditure in total health expenditure (pub), share of individuals aged above 65 in the total population (age65), total population (pop) and life expectancy (life), all in log unit. Therefore, our empirical model is now extended to

$$\ln(m/l)_{it} = \alpha + X'_{it}\beta + \delta_i + u_{it} \tag{10}$$

where α is the constant term, X is the vector of regressors with $\ln(p/w)$ as the first regressor, δ_i is the unobserved individual effect, and u_{it} is the error term. We are interested in the coefficient β_1 before the dependant variable $\ln(p/w)$. We again do not have any prior information regarding unobserved individual effect δ_i and the regressors in X. Therefore for each empirical model, we conduct F test (Wald test) for the fixed effect model and Breusch-Pagan Lagrange Multiplier (LM) test for random effect. If both tests reject H_0 hypothesis, which is the case for all empirical models here, we then run Hausman test to detect whether FE or RE is appropriate for each specification of equation (10).[22] We present both FE and RE results for each empirical model in Table 5.

First, we add the share of public health expenditure in total health expenditure into the right-hand side of equation (9). The reason we think that pub is a reasonable control is it captures the differences in health care system in our sample countries. For the countries adopt universal health care system such as UK, this share is in general much higher than the one in the countries which do not adopt the universal health care system, such as US. This ratio is 81.9% in UK in 2005, compared to 45.5% in the US in the same year. By adding in this variable, we are able to further control the institutional factors across countries that cannot be captured in the benchmark estimation equation (9). Notice that as a proxy for health care system, pub can possibly affect the dependant variable $\ln(m/l)$. On one hand, higher degree of government intervention into the health care market could lead to moral hazard problem that could increase the usage of medical care;[23] On the other hand, higher degree of government intervention into the health care system could also impose more restriction and rationing in health care and hence decreases the usage of health care.[24] As an evidence, Table 3 shows the correlation between ln(pub) and

[22] Follow the convention in the literature, we use 5% as criteria to evaluate the significance of Hausman test result. If $Prob > \chi^2$ is less than 5%, we reject the null hypothesis of Hausman test and accept FE as the appropriate model.

[23] See Card, Dobkin, and Maestas (2008) and Anderson, Dobkin and Gross (2012).

[24] Some anecdotal evidences about the rationing of health care in UK are reported at http://www.nytimes.com/2008/12/03/health/03nice.html?pagewanted=1&_r=2 and http://www.pri.org/stories/health/how-the-uk-rations-health-care.html.

the dependant variable ln(m/l) is 0.21, which indicates that the moral hazard effect on the demand side of health care probably dominates the rationing effect on the supply side. Public health care system usually imposes a price control on health care. Therefore it is not surprising to see the correlation between ln(pub) and ln(p/w) is -0.28.

Besides ln(p/w), with ln(pub) as an additional regressor, we run both FE and RE estimation to equation (10) (we call it Model I). With $F = 5.26$ for F-test for FE and $\chi^2 = 7.28$ for LM test, we reject both H_0 hypothesis at 1% significance level and find FE and RE present. With $Prob > \chi^2 = 0.0007$, Hausman test suggests that FE is an appropriate model. FE results show that β_1 is -1.1573, close to the one obtained in the benchmark estimation equation (9). And it is significant at 1% level. The coefficient before ln(pub) is 1.9729 and it is significant at 1% level. It shows an increase in the share of public health expenditure in total health expenditure by 1% will increase the ratio of health-related consumption good to leisure time by about 2%, holding all other variables constant.

Second, we control the share of individuals aged above 65 in the total population (age65) in equation (10). With the facts that medical expenditures rise dramatically over the life cycle and especially speed up after retirement (see Hagist and Kotlikoff 2009, Jung and Tran 2010, Halliday, He and Zhang 2012) and leisure time jumps after retirement, we believe this share should affect m/l ratio. Table 3 also shows that the correlation between ln(m/l) and ln(age65) is quite positive at 0.5435. With both ln(p/w) and ln(age65) as regressors, we run both FE and RE estimation to equation (10) (we call it Model II). With $F = 3.51$ for FE and $\chi^2 = 7.51$ in LM test for RE, we reject both H_0 hypothesis and find FE and RE present. With $Prob > \chi^2 = 0.0806$, Hausman test accepts the null hypothesis and suggests that RE is an appropriate model. The lower panel of the third column in Table 5 reports the RE estimation results. β_1 is -1.2433 and it is significant at 1% level, quite close to the one obtained in the benchmark estimation equation (9). The coefficient before ln(age65) is 0.2473 and it is significant at 10% level.

Third, we add the total population (pop), together with ln(p/w), in estimation equation (10) to control the possible size effect on medical expenditures (we call the estimation equation Model III). Both F test and LM test reject the null hypothesis and find FE and RE. Hausman test suggests that RE is an appropriate model for this specification ($Prob > \chi^2 = 0.0555$). The RE estimation results are reported in the lower panel of the fourth column in Table 5. Table 3 shows that the correlation between ln(pop) and dependant variable ln(m/l) and other regressors is very low. Therefore it is not surprising to see the estimated β_1 is -1.3478 at 1% significance level, very close to $\beta_1 = -1.3462$ in the benchmark estimation. The coefficient before ln(pop) is 0.0045 and it is not statistically significant.

Fourth, we add the life expectancy (life) as a regressor, together with $\ln(m/l)$ in estimation equation (10) (we call it Model IV). We think the life expectancy could be an useful control for two following reasons. First, life expectancy is a commonly used measure for health status (see Bloom, Canning and Sevilla 2004), therefore adding life expectancy in regressors could help to control the cross-country difference in health status in the regression. Second, a higher life expectancy implies a higher share of individuals aged above 65 in the total population (in Table 3, the correlation between ln(life) and ln(age65) is 0.41), which leads to possible higher usage of health care. As an evidence, Table 3 shows that ln(life) is highly positively correlated with dependant variable $\ln(m/l)$. However, as a regressor, ln(life) has a multi-collinearity problem with the main regressor $\ln(p/w)$ that is derived from our structural framework. As Table 3 shows, the correlation between ln(life) and $\ln(p/w)$ is 0.65. This multi-collinearity problem disqualifies ln(life) as a good control in the estimation. With $F = 3.51$ for FE and $\chi^2 = 7.51$ in LM test for RE, we find FE and RE both present. We therefore conduct FE and RE estimation to equation (10) with both $\ln(m/l)$ and ln(life) as regressors in the fifth column in Table 5. Hausman test accepts FE as a more appropriate model for the estimation at 1% significance level ($Prob > \chi^2 = 0.0010$). In FE model, β_1 is -0.6609 at 5% significance level. Compared to all other cases in Tables 4 and 5, the decrease in significance level is also an informal sign of possible multi-collinearity problem caused by adding ln(life). Since ln(life) and $\ln(m/l)$ is highly correlated, it is not surprising to see the coefficient before ln(life) is 17.1427 at 1% significance level.

From the analysis above, we find that among four controls we add, ln(pub) and ln(age65) have significant impact on the dependant variable $\ln(m/l)$. However, ln(life) has a multi-collinearity problem. And ln(pop) has a very low correlation with $\ln(m/l)$ and other regressors and the coefficient before it is insignificant. Therefore, we remove both ln(life) and ln(pop) from the candidate of controls for the extended empirical model and run an estimation of equation (10) with three regressors: $\ln(p/w)$, ln(pub) and ln(age65). We call this specification Model V and we believe that it should be the final form of our extended empirical model. F test yields $F = 4.97$ and p-value is 0.000. LM test generates $\chi^2 = 4.91$ with $p = 0.0134$. Both FE and RE exist. We report both FE and RE estimation results in the sixth column in Table 5. Hausman test accepts FE as a more appropriate model for the estimation at 1% significance level ($Prob > \chi^2 = 0.0004$). The RE results shows that β_1 is -1.0377 and it is significant at 1% level. The coefficients before ln(pub) and ln(age65) are consistent to the ones obtained in Model I and II and the significance level of the estimation is similar.

Finally, we include all four controls together with $\ln(p/w)$ in Model VI. With $F = 5.86$ for FE and $\chi^2 = 5.64$ in LM test for RE, we find FE and RE both present. For this specification, Hausman test suggests accepts FE as a more appropriate model for the estimation at 1% significance level ($Prob > \chi^2 = 0.0004$). The FE results are reported in the upper panel of the seventh column in Table 5. Once we add in ln(life) which has the multi-collinearity problem, β_1 drops dramatically to -0.7196. For all the controls, only the coefficients before ln(pub) and ln(life) are significant.

In summary, by adding in four possible controls into our core estimation equation, we see the coefficient β_1 is lower than the benchmark value as shown in Table 4. However, even in the specification that might be subject to multi-collinearity problem and hence tends to downward bias the estimation, we still see a significant number (-0.6609).[25] Therefore, we conclude that we find a significant elasticity of substitution between two primary inputs in health production function, namely health-related consumption and leisure time, in the range from 0.66 to 1.35.

4.4 Robustness Check

In this section, we do two experiments to check the robustness of our estimation results to a different sample selection and data construction method. We report the estimation results in Table 6. To save the space, we only report the FE and RE results for the benchmark estimation equation (9) and the Model V for extended empirical model equation (10).

First, since many studies argue that the US is an outlier in terms of health expenditures (e.g., Pearson 2009, Comanor et al. 2006), we redo the estimation by dropping the US from the data set. The first case in Table 6 reports the results. F test and LM test again find that both FE and RE exist. Hausman test suggests that RE is a more appropriate model in the benchmark case while it accepts FE in Model V. β_1 thus is -1.3082 in the benchmark case and -1.0391 in the model with $\ln(p/w)$,

[25] WE have also added other possible controls in the extended empirical model but they do not change our results significantly. For example, as suggested by Hall and Jones (2007) as a possible input in health production function, we add education level which is measured by the gross school enrollment rate for tertiary education (data source: World Bank WDI) as a control. We test different specifications for equation (10). With both $\ln(p/w)$ and ln(edu) as regressors, FE results show $\beta_1 = -1.1541$ and RE results are $\beta_1 = -1.3307$. Hausman test suggests RE. Add ln(edu) into Model V as an additional control, β_1 changes to -0.9972 under FE and -1.2438 under RE. Hausman test suggests RE. Finally, if we add ln(edu) into Model VI together with all four controls, β_1 changes to -0.7087 under FE and -0.9811 under RE. Hausman test again suggests RE. β_1 is significant at 1% level for all the cases. Coefficient before ln(edu), however, is not statistically significantly in almost all the cases. The results on the estimation of β_1 thus is largely similar to the ones reported in Table 5.

ln(pub) and ln(age65) as regressors (Model V). Both are very close to the values obtained using the full sample. It is clear that dropping the US does not change our estimation results significantly.

Second, more than one third of health expenditures occur to the elderly in developed countries (see Anderson and Hussey 2000), therefore constructing data by per working age population, as shown in Section 3, might potentially ignore the effect of the age structure of the total population on the dependant variable m/l. To check the robustness of our results, we divide the constructed data in Section 3 by total population in each country and redo the exercise in Section 4.2 and 4.3. The results are reported in the second case in Table 6. Hausman test suggests to use RE in the benchmark case and FE for Model V. As one can see, changing the data from per working age population to per capita does not significantly affect our empirical results. β_1 is very close to the one obtained in both benchmark estimation and Model V in Tables 4 and 5.

Given these results, we can safely conclude that for most cases, the estimation of coefficient β_1 is robust to different sample selections and an alternative data construction method. We thus claim that the model-based estimation of elasticity of substitution between health-related consumption m and leisure time l in health production is around 1.35.

5 Policy Implication

In this section, we would like to go back to the question raised in the introduction: besides improving public health status, would the national campaigns such as "Let's Move!" also achieve the goal of reducing national health expenditure and hence help to relieve some pressure on the fiscal uncertainty? If the answer is yes, how much medical expenditure can be saved through increasing leisure activities?

Based on our model-based estimation of estimation of elasticity of substitution between m and l, we can do the following "back-of-envelope" calculation to determine the effect of increasing leisure time on reducing national health expenditures, given we maintain our health status. Americans spent 4614 hours per year or 79% of their annual discretionary time in enjoying leisure in 2008. Suppose "Let's Move!" or NCPPA can successfully encourage Americans to increase their daily time for physical activity or health-enhancing leisure time by one hour, that translates into a 7.9% increase in the share of leisure time in total annual time endowment. Given the elasticity of substitution between m and l is 1.35, this in turn translates into a $1.35 \times 7.9\% = 10.7\%$ decrease in real health-related consumption per working age population m in 2008, i.e., decrease \$1070 (in 2005 dollars) from \$9997 to \$8927.

With $p = 1.15$ in 2008, this is equivalent to a reduction of health expenditure per working age population \$1230 and totally a reduction of national health expenditure 251 billion 2005 dollars, which accounts for about 10.7% of the real national health expenditure in 2008.[26]

Americans on average spend far more than one hour in sedentary activities such as "couch potato." According to American Time Use Survey (ATUS), in 2008, Americans on average spent 2.77 hours per day on watching TV. Among people who watch TV everyday (ATUS reports the percentage of this fraction is 80.9% in 2008), they watch on average about 3.43 hours. Encouraging people to switch from watching TV to health-enhancing leisure activities such as exercising, recreationing, or gardening, or at least combining watching TV with those activities, will also largely affect national health expenditure since as we argued in Section 2, β_1 still measures the elasticity of substitution between health-related consumption and further differentiated health-enhancing leisure time. In the same spirit, a switch from 2.73 hour "couch potato" time to health-enhancing leisure activities will translate into a $1.35 \times 2.77 \times 7.9\% = 29.5\%$ decrease in real health-related consumption per working age population m in 2008. This is equivalent to a reduction of health expenditure per working age population \$3396 and totally a reduction of national health expenditure 693 billion 2005 dollars, which accounts for about 29.5% of the real national health expenditure in 2008.

To put this number in the fiscal perspective, in 2008, the fiscal deficit accounted for 5.29% of GDP in the US, which was 693 billion 2005 dollars. This is exactly the same amount of national health expenditure could be saved if we encourage an average American to switch her TV watching time to health-enhancing leisure time. By doing so, we can successfully "kill two birds with one stone." We let Americans move out their couch to do more exercise and hence improve their health status. In the long run, this will raise their labor productivity as well. On the other hand, switching from a sedentary lifestyle to a more healthy and active way will also "bend the cost curve" and stop the seemly unstoppable rising trend in health care cost. And as we show here, it directly helps to eliminate fiscal deficit and hence gives us a hope to resolve the long run fiscal uncertainty.

[26] A series of medical studies investigate the economic costs of inactivity and obesity using micro-level data. For example, Colditz (1999) assesses the economic costs of inactivity which include direct costs resulting from treatment of morbidity and indirect costs caused by lost productivity and forgone earnings caused by premature mortality. He finds that the total costs of inactivity and obesity account for some 9.4% of the national health care expenditures in the US. This percentage is also close to what Finkelstein et al. (2003) find, which is 9.1%. Wang and Brown (2004) find that 6.1% of medical expenditure is inactivity associated among adults, controlling for frequency of feeling downhearted or blue. Our number here is in line with their findings.

6 Conclusion

Nowadays, the US is facing two pressing national issues: one is with the highest medical expenditures in the world, the US remains the most unhealthy country among comparable rich countries. How can we improve our national health status? Another one is related to rapidly rising government debt and looming fiscal uncertainty. What should we do to avoid a long run fiscal collapse?

In this paper, we build a natural connection to bridge these two apparently distinct policy issues. The key is leisure time. We argue that increasing health-enhancing leisure time may substantially reduce national health expenditure while maintaining national health status, and thus may also provide a hopeful resolution to the pressing fiscal uncertainty. To this end, we first propose a macroeconomic general equilibrium framework to study the relationship between two primary inputs in health production function: health-related consumption and leisure time. We then estimate the elasticity of substitution between these two inputs in health production based on the general equilibrium framework using a short panel of cross-country data. We find that the elasticity of substitution is in the range from 0.66 to 1.35, depending on different specifications of the empirical model. Based on the estimation results, an increase in health-enhancing leisure time such as physical activities by one hour per day, as recommended by national initiatives such as "Let's Move!", could have decreased the national health expenditure by 251 billion dollars, which accounted for about 10.7% of real national health expenditure in 2008. In addition, if we can successfully switch our daily "couch potato" time to health-enhancing leisure time, it would reduce national health expenditure by 693 billion dollars. This was the exact amount of total US fiscal deficit in 2008. For a country facing the severe budgetary issue and rising national debt, the exercise done in this paper might provide an alternative for solving the fiscal crisis from a different perspective.

7 Appendix

The simple theoretical framework we laid out in Section 2 is a highly stylized one which only describes the production side of health just for presentation purpose. In this appendix, we extend this framework to a truly general equilibrium (GE) model which includes the demand side of health by seriously modelling the consumer's problem. The theoretical framework in the text thus is embedded in a full-blown GE setting which is the framework that has been widely employed in macro health literature. We then re-construct the data according to this general equilibrium framework and rerun the empirical exercises in the text. We find that our empirical results are largely similar to the ones in the text based on a partial equilibrium production-based model. Therefore, our empirical results still hold in a general form.

7.1 General Equilibrium Theoretical Framework

Our model economy consists of a large number of identical agents and a large number of perfectly competitive firms. A representative agent chooses the consumption of non-medical and medical commodities, the time allocation between paid work and leisure, physical and health capital to maximize her discounted lifetime utility

$$\sum_{t=0}^{\infty} \beta^t \pi(h^t) U(c_t, h_t),$$

where c_t represents non-medical consumption and h_t is health stock at time t,[27] subject to following budget constraint

$$c_t + p_t^m m_t + k_{t+1} = w_t n_t + (r_t + 1 - \delta_k) k_t + \Pi_t,$$

where m_t is the health-related consumption and p_t^m represents the relative price of medical consumption in terms of non-medical consumption which is the numeraire of the economy. r_t is the rental rate of physical capital k_t. The physical capital depreciates at an annual rate of δ_k. Π_t is the profit distributed back to agents by the firms. Notice that $\pi(h^t)$ represents the unconditional survival probability at time t (i.e., the probability that an agent survives up to time t) which depends on the history of health status $h^t \equiv (h_0, h_1, ...h_t)$. And π is a positive function of h^t. Better health extends your life (Hall and Jones 2007). In this model, an individual values health because it allows her to live longer and enjoy higher utility in each period.

A representative firm employs inputs of physical capital k_t and labor n_t to produce output g_t according to a constant-returns-to-scale production technology, which we assume that it takes Cobb-Douglas form

$$g_t = F(k_t, n_t) = k_t^{\alpha} n_t^{1-\alpha}. \tag{11}$$

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 rate as given. The firm's profit is determined by the following equation

$$\Pi_t = F(k_t^d, n_t^d) - r_t k_t^d - w_t n_t^d.$$

[27] Notice that health stock directly enters into the utility function here, which captures so-called "consumption motive" for health investment as emphasized in Grossman (1972).

We assume that the health stock of the representative agent at time t, h_t, is produced by a production function $H(m_t, l_t)$ which uses health-related consumption and leisure time as inputs. The accumulation of health stock is described by the following equation

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

where δ_h is the depreciation rate of health capital. Notice that this specification is a simplified version of the model estimated by Sickles and Yazbeck (1998).

Finally, a representative agent is endowed a unit of one discretionary time in every period. This time endowment is divided between paid work and leisure which is an important input in producing health capital.

$$1 = n_t + l_t. \tag{12}$$

A competitive equilibrium for this model economy is an allocation $\{c_t, m_t, n_t, l_t, k_{t+1}, h_{t+1}\}$ for the agents, an allocation $\{k_t^d, n_t^d\}$ for the firms, and the factor prices $\{w_t, r_t\}$ for all $t \geq 0$, such that: (1) Given factor prices and exogenous relative price of health-related consumption p_t^m, the allocation $\{c_t, m_t, n_t, l_t, k_{t+1}, h_{t+1}\}$ solves the agent's optimization problem; (2) Given factor prices, the allocation $\{k_t^d, n_t^d\}$ solves the firm's profit maximization problem; (3) Markets clear, i.e., we have $c_t + m_t + i_t = g_t$, where $i_t = k_{t+1} - (1 - \delta_k)k_t$ is the physical capital investment, $n_t = n_t^d$, $k_t = k_t^d$.

It is easy to show (after some algebra), using the agent's optimization conditions and the firm's first-order condition, we have following intra-temporal optimization condition

$$\frac{\partial H / \partial m_t}{\partial H / \partial l_t} = \frac{p_t^m}{w_t}. \tag{13}$$

This equation is exactly identical to the one we derived in the text (see equation 2) except now the numeraire changes from output to non-medical consumption, therefore the relative price of health care changes from p_t, which is in terms of general price level in the economy, to p_t^m which is in terms of non-medical consumption c_t.

Assuming the health production function takes the CES form as in the text (equation 3), we still obtain the identical model-based benchmark estimation equation (9).

7.2 Data Construction

We use the same dataset as in the text. However, since the model has been changed to a general equilibrium one and the numeraire in the model economy has been changed as well. This especially affects the measurement of relative price of health care p_t^m and health-related consumption m_t. Therefore, to closely follow our new theoretical framework, we have to re-construct these two measurements.

7.2.1 Measures of relative price of health-related consumption

The measurement of the relative price of health-related consumption p_t^m again comes from OECD data. As we emphasized in Section 3.1, we rely on Table A2 in the OECD PPP Benchmark Results to construct p_t^m for $t = 2005$ and 2008. However, different from the text, we can not divide column 19 directly by column 1 to obtain the data counterpart of p_t^m any more since p_t^m is not in terms of general price level in the economy but non-medical consumption c_t. We therefore construct the data of p_t^m in following detailed procedure:

1. Table A2 reports GK method-based PPP-adjusted price level of health care in column 19 (we denote it as p^h) and price level of actual individual consumption in column 2 (we denote it as p^{tc}). Use column 2 to divide column 19, we have the data counterpart of relative price of health care in terms of total consumption goods. Let's call it $p_{htc} = p^h/p^{tc}$.

2. According to OECD, PPP-based price level of total individual consumption is a weighted sum of PPP-adjusted price level of health care and non-medical consumption goods with the weights reflecting their shares in total nominal consumption. Let's define total nominal medical expenditure to be $\tilde{m}$ and total nominal non-medical consumption expenditure to be $\tilde{c}$. We have
$$p^{tc} = \frac{\tilde{m}}{\tilde{m}+\tilde{c}} p^h + \frac{\tilde{c}}{\tilde{m}+\tilde{c}} p^c. \tag{14}$$
We construct the share of health expenditure in total consumption $\tilde{m}/(\tilde{m}+\tilde{c})$ as follows. First, we obtain nominal GDP (call it $\tilde{g}$) and actual individual consumption expenditure (data of $\tilde{m}+\tilde{c}$) from OECD Stat.[28] We divide the actual individual consumption expenditure by GDP to get $(\tilde{m}+\tilde{c})/\tilde{g}$. Second, we obtain the nominal medical expenditure-GDP ratio $\tilde{m}/\tilde{g}$ from OECD Health data 2012. The share of health expenditure in total consumption thus is just $\tilde{m}/\tilde{g}$ divided by $(\tilde{m}+\tilde{c})/\tilde{g}$.

3. Once we have all the data in equation (14), We can map relative price of health care in terms of total consumption goods to the relative price of health care in terms of non-medical consumption goods according to equation (14) as follows
$$p^m \equiv \frac{p^h}{p^c} = \frac{\frac{\tilde{c}}{\tilde{m}+\tilde{c}}}{\frac{p^{tc}}{p^h} - \frac{\tilde{m}}{\tilde{m}+\tilde{c}}}$$

[28]The data of GDP is GDP (expenditure approach) from OECD stat (http://stats.oecd.org), transaction B1_GE. The data of actual individual consumption is transaction P_41. Both are in terms of national currency, current price, million dollars.

where the data of p^{tc}/p^h are taken from the first step and the data of $\tilde{m}/(\tilde{m}+\tilde{c})$ and $\tilde{c}/(\tilde{m}+\tilde{c})$ are taken from the second step.

The second and third column in Table 7 show the relative price of health-related consumption p^m in 35 countries for 2005 and 2008. Notice that the US has relatively higher medical care price than most of the countries in our data set.

7.2.2 Measures of health-related consumption

The measurement of health-related consumption good m_t comes from World Bank and OECD. The key here is, to be consistent with our general equilibrium model and the construction of p^m in last section, we have to measure health-related consumption in terms of total consumption and it has to be PPP-based. We therefore construct m_t as follows:

1. From OECD National Accounts of GDP (expenditure approach), we obtain the data of actual individual consumption (transaction P_41), which is PPP-based in terms of constant 2005 international dollars (measure VPVOB in OECD Stat). Let's call it C_t.[29]

2. Multiply C_t by the share of medical expenditure in total actual individual consumption $\tilde{m}_t/(\tilde{m}_t+\tilde{c}_t)$ that we constructed in last section, we have the PPP-based real health expenditure, which is the data counterpart of $p_t^m m_t$ in our model.[30]

3. We then divide the PPP-based real health expenditure in the second step by the relative price of health-related consumption p_t^m which we constructed in last section to obtain health-related consumption m_t.

The fourth and fifth column in Table 7 show the data of m_t in 2005 and 2008 respectively. Notice that the US still has the highest "quantity" of health care in

[29] OECD does not report the data of actual individual consumption for Malta and Cyprus. We therefore use the data of household final consumption (PPP-based, constant 2005 international \$, data source: World Bank WDI) for C_t for those two countries. Our estimation results do not change significantly even if we drop those two countries from the dataset. For example, dropping Malta and Cyprus from our dataset, we run again both FE and RE estimation to equation (9), β_1 is -0.9648 in FE model and -1.1423 in RE model, compared to -0.9706 and -1.1556 using the full sample of 35 countries as shown in Table 8.

[30] Notice that the share of medical expenditure in total actual individual consumption is unit free as long as the numerator and denominator is on the same basis.

our data set when we control the effect of relative price of health care, the same as in the text.

Since the production function and the time constraint do not change in the current general equilibrium setting compared to the model in the text, the construction of real annualized wage and leisure time is the same as in the text. Therefore the data of w_t and l_t remain the same in Table 7 as in Table 1.

7.3 Empirical Results

We first show the estimation results of benchmark empirical equation (9) in Table 8. F test for the fixed effect model ($F = 24.65$ with $p = 0.000$) and Breusch-Pagan Lagrange Multiplier (LM) test ($\chi^2 = 27.70$ and $p = 0.000$) both reject the null hypothesis. Therefore both FE and RE effect present and we conduct both FE and RE estimation. The results are shown in the second and third column in Table 8. To check the robustness of RE results, we also run MLE and bootstrap estimation of the RE model. The results are shown in the fourth and fifth column in the same table. All three RE results come very close. However, Hausman test accepts FE model at 5% significance level with $Prob > \chi^2 = 0.0338$. As shown in the second column in Table 8, the coefficient before $\ln(p^m/w)$–β_1 is -0.9706 and it is significant at 1% level. That implies the elasticity between health-related consumption and leisure time in health production is 0.97. It is lower than the number (1.35) we obtain in the text but it is still very significant.

We also run the extended estimation equation (10) as in Section 4.3 using the re-constructed data in Table 7. For each specification, we again run F test, LM test and Hausman test to determine the appropriate empirical model we should use. Again for all the cases, we have a very significant p-value for both F and LM test. We therefore report both FE and RE results for each case in Table 9. In Model I, Hausman test rejects the null hypothesis at 5% significance level with p-value $Prob > \chi^2 = 0.0195$, which suggests that FE is a more appropriate model. The FE estimation results for Model I shows that β_1 is -0.9149 and it is significant at 1% level. Hausman test suggests that RE is appropriate for Model II while it suggests to accept FE for Model III. β_1 is -1.0471 and -0.8386 in each case, respectively. We also want to point out in model IV, when we include ln(life) as an additional control together with $\ln(p^m/w)$, we might introduce a possible multicollinearity problem since the correlation between ln(life) and $\ln(p^m/w)$ is -0.6418. As an evidence of possible multicollinearity problem, we see the coefficient β_1 decreases significantly to -0.7460 (Hausman test suggests to accept FE with $p = 0.0394$) compared to other models in Table 9. Therefore a caveat should be emphasized for the results of model

IV. Similar to the discussion in text (see Section 4.3), we think Model V is a more appropriate specification of the extended model. The results are shown in the sixth column of Table 9. With $Prob > \chi^2 = 0.0350$, Hausman test suggests that we accept FE as a more appropriate model. β_1 in FE model is -0.8695 and it is significant at 1% level. When we include all possible controls in model VI (the seventh column in Table 9), Hausman test suggests RE model. The RE results show that β_1 is -0.9312 and it is significant at 1% level. In summary, GE model-based estimation in Table 8 and 9 show that the elasticity of substitution between health-related consumption and leisure time in health production function is in the range from -0.75 to -1.16, which largely overlap with the range we estimated in the text based on a simple health production optimization problem. Notice that the mean value of the elasticity in that range is 0.96, very close to the one obtained in the text, which is 1.

Finally, to check the robustness of the empirical results, we also re-run the two exercises in Section 4.4 in the text, i.e., dropping US from our sample and reconstruct data in terms of per capita, Table 10 shows the results.[31] The results are very close to the ones presented in Table 8 and 9. We thus conclude that our GE model based structural estimation yields a very robust empirical results about the elasticity of substitution between two major inputs in health production function.

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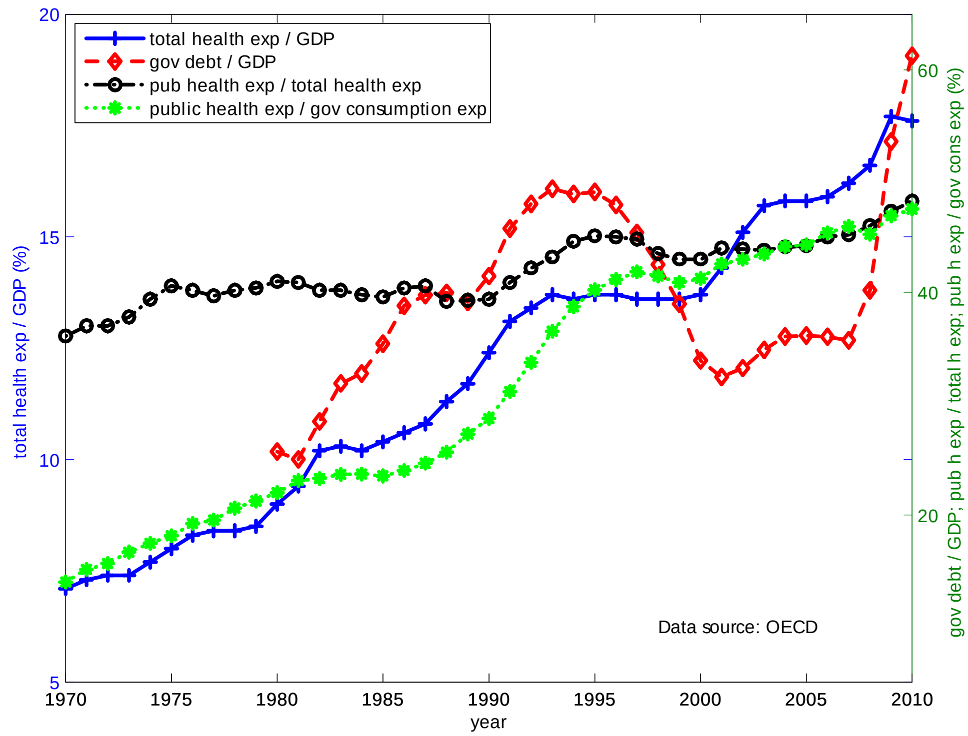

Figure 1: Total health expenditure, public health expenditure and central government debt in US

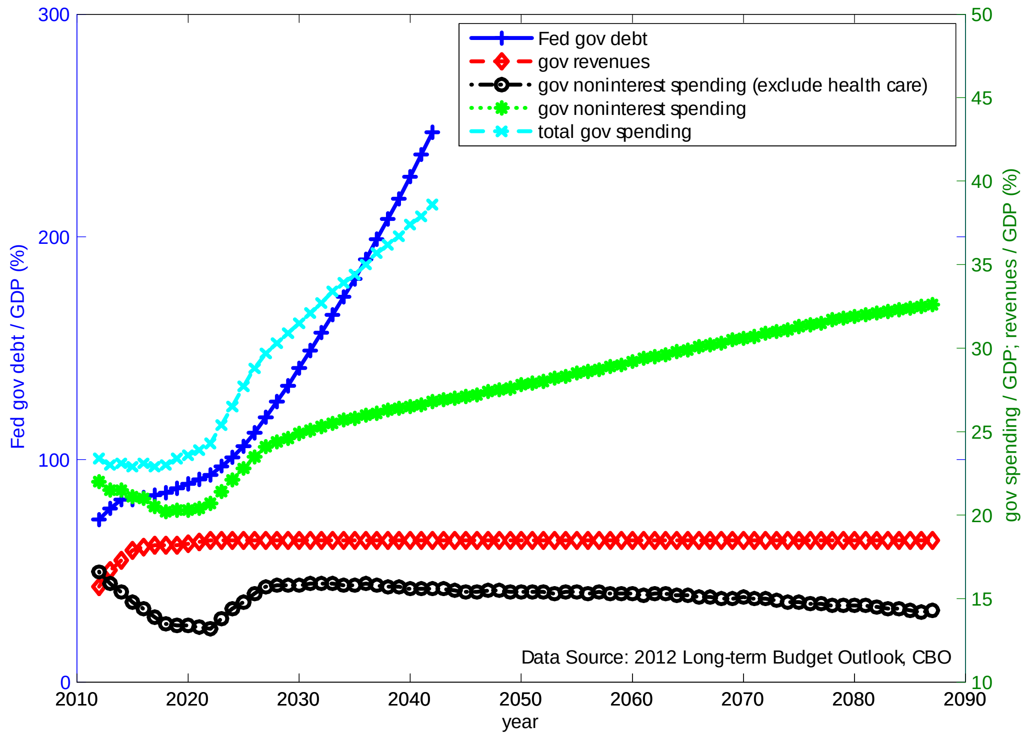

Figure 2: The long-term projections of US federal government spending, revenue and debt as a share of GDP

Table 1: Cross-country comparison of relative price of health care, health-related consumption, annual wage, and fraction of leisure

	p (PPP)		m (PPP, 2005 $)		w (PPP, 2005 $)		l (%)	
Country	**2005**	**2008**	**2005**	**2008**	**2005**	**2008**	**2005**	**2008**
Australia	0.96	0.93	4609	5417	30909	32386	78.0	77.9
Austria	0.99	1.08	5159	5640	31737	34177	79.6	79.1
Belgium	1.02	1.06	4899	5321	31288	32641	83.5	83.0
Canada	1.27	1.15	3737	4993	32363	33060	78.3	78.0
Cyprus	1.06	0.98	2082	2711	16536	17743	83.8	83.4
Czech Republic	0.75	0.78	2769	3164	19162	21812	76.9	76.2
Denmark	1.08	1.14	4404	5368	32117	33156	79.4	78.4
Estonia	0.77	0.81	1583	2427	15544	17744	77.3	76.2
Finland	1.18	1.06	3287	4471	29480	32118	79.9	79.2
France	1.07	0.97	4726	6018	28934	29751	83.7	83.5
Germany	0.95	0.93	5292	6425	29842	32647	82.6	82.0
Greece	0.89	0.86	3920	5195	23155	25017	78.3	77.0
Hungary	0.84	0.81	2446	2680	15799	16629	79.5	79.8
Iceland	1.21	1.08	4140	5055	33724	35003	74.8	74.0
Ireland	1.07	1.30	3927	4272	36420	37085	77.6	78.0
Israel	1.16	0.93	2477	3573	24050	26309	79.0	77.8
Italy	1.22	1.12	2983	4076	27305	27629	80.4	80.2
Japan	0.82	0.91	4548	4863	29369	30830	76.8	76.5
South Korea	0.57	0.71	3162	3367	20361	22495	73.2	74.2
Luxembourg	1.16	1.15	6915	7778	65153	68007	73.7	71.9
Malta	0.85	0.86	7005	3450	19372	20770	79.6	81.8
Mexico	0.97	0.89	1179	1566	12378	12901	77.0	77.0
Netherlands	0.93	0.95	5490	6610	33278	36224	82.1	81.4
New Zealand	1.06	0.95	3116	4251	24376	24041	77.2	77.7
Norway	1.31	1.38	4983	5702	46430	46791	81.2	79.9
Poland	0.69	0.89	1766	1992	12546	14760	81.3	79.5
Portugal	1.13	1.11	2756	3367	20319	21014	76.2	76.2
Slovak Republic	0.75	0.84	2127	3053	14498	18008	83.6	82.7
Slovenia	1.02	0.93	2757	3751	21384	24883	80.8	79.6
Spain	0.92	1.03	3557	4212	25501	26495	81.6	81.4
Sweden	1.15	1.08	3928	5145	32031	33486	79.7	79.1
Switzerland	0.84	0.81	7018	8856	34837	37154	76.3	75.8
Turkey	0.91	1.05	1034	1291	11124	11846	85.0	85.0
UK	1.03	1.00	3958	4882	31919	32893	80.6	80.8
US	1.16	1.15	8035	9997	40522	41051	78.9	79.0

Data source: OECD, World Bank and Conference Board Total Economy Database.

Notes: p is the relative price of health-related consumption in terms of general price level. m is the real annual health-related consumption per working age population. w is the real annualized wage per working age population. l is the fraction of leisure time in annual time endowment per working age population.

Table 2: Summary statistics of variables

Variable (Unit)	Mean	Median	Std. Dev.	Min	Max	N
m/l (2005 international \$)	5374.32	5080.94	2359.23	1216.93	12652.39	70
p/w (10^{-5} 2005 international \$)	3.95	3.53	1.39	1.69	8.86	70
public health exp. share (%)	70.38	73.02	11.14	38.96	84.95	70
>65 population (%)	14.43	14.68	3.45	5.66	21.46	70
total population	3.41E+07	10330082	5.62E+07	296734	3.04E+08	70
life expectancy (year)	78.75	79.39	2.51	72.08	82.59	70

Data source: OECD, World Bank and Conference Board Total Economy Database.
Notes: m/l is the ratio of health-related consumption good to leisure time which is constructed by the authors. p/w is the ratio of the relative price of health-related consumption good to wage constructed by the authors. The data of the share of public health expenditure in total health expenditure, share of individuals aged above 65 in the total population, total population and life expectancy are taken from World Bank.

Table 3: Correlation matrix of variables

Variable	ln (**m/l**)	ln (**p/w**)	ln(**pub**)	ln(**age65**)	ln(**pop**)	ln(**life**)
ln (**m/l**)	1.0000					
ln (**p/w**)	-0.8982	1.0000				
ln(**pub**)	0.2071	-0.2807	1.0000			
ln(**age65**)	0.5435	-0.4957	0.4615	1.0000		
ln(**pop**)	-0.0678	0.0904	-0.1964	-0.0450	1.0000	
ln(**life**)	0.7083	-0.6462	0.1279	0.4120	-0.0277	1.0000

Table 4: Estimation results of equation 9

Variable	FE	RE	MLE	Bootstrap
$\ln(m/l)$	-1.3322***	-1.3462***	-1.3463***	-1.3462***
	(0.3104)	(0.0952)	(0.0932)	(.0865)
F-statistic	18.41	200.13	80.21	N/A
$p > \chi^2$	0.000	0.000	0.000	N/A
adjusted R^2	0.9000	N/A	N/A	N/A

Notes: N=70. Standard errors are shown in parentheses. *** significant at the 1% level. ** significant at the 5% level. * significant at the 10% level. F-statistic and associated p-value measure overall goodness-of-fit of the model.

Table 5: Estimation results of equation 10

Model	**I**	**II**	**III**	**IV**	**V**	**VI**
Variable			Fixed effect			
ln(p/w)	-1.1573***	-1.0642***	-0.9727***	-0.6609**	-1.0377***	-.7196***
	(0.2477)	(0.2952)	(0.3080)	(0.2485)	(0.2501)	(0.2429)
ln(pub)	1.9729***				1.6722***	1.0156**
	(0.4240)				(0.4463)	(0.4426)
ln(age65)		2.7527***			1.5021*	-1.0483
		(0.9395)			(0.8626)	(1.0773)
ln(pop)			3.4241***			0.0276
			(1.1877)			(1.0865)
ln(life)				17.1427***		15.8769***
				(2.9235)		(5.1208)
F-statistic	25.62	15.55	15.34	35.43	19.15	17.10
$p > \chi^2$	0.000	0.000	0.000	0.000	0.000	0.000
adj R^2	0.9378	0.9182	0.9177	0.9495	0.9414	0.9546
Variable			Random effect			
ln(p/w)	-1.3245***	-1.2433***	-1.3478***	-1.0422***	-1.2417***	-0.9837***
	(0.1099)	(0.1099)	(0.1009)	(0.1264)	(0.1169)	(0.1350)
ln(pub)	0.1407				-0.0200	0.0966
	(0.1954)				(0.2042)	(0.2023)
ln(age65)		0.2473*			0.2630*	0.1534
		(0.1276)			(0.1481)	(0.1490)
ln(pop)			0.0045			0.0041
			(0.0202)			(0.0209)
ln(life)				4.8652***		4.6297***
				(1.2682)		(1.3110)
F-statistic	161.82	199.09	179.16	200.65	176.16	197.26
$p > \chi^2$	0.000	0.000	0.000	0.000	0.000	0.000

Notes: N=70. Standard errors are shown in parentheses. *** significant at the 1% level. ** significant at the 5% level. * significant at the 10% level. F-statistic and associated p-value measure overall goodness-of-fit of the model.

Table 6: Robustness check of estimation

Case	**Drop US**		**Per capita**	
Model	**Benchmark**	**Model V**	**Benchmark**	**Model V**
Variable	Fixed effect			
$ln(p^m/w)$	-1.3236***	-1.0391***	-1.3089***	-1.0117***
	(0.3117)	(0.2513)	(0.3027)	(0.2442)
ln(pub)		1.6818***		1.6546***
		(0.4486)		(0.4448)
ln(age65)		1.4152		1.5248*
		(0.8731)		(0.8593)
F-statistic	18.03	18.61	18.70	19.25
$p > \chi^2$	0.000	0.000	0.000	0.000
adj R^2	0.8919	0.9365	0.8986	0.9405
Variable	Random effect			
$ln(p^m/w)$	-1.3082***	-1.1601***	-1.3202***	-1.2072***
	(0.0877)	(0.1081)	(0.0972)	(0.1187)
ln(pub)		0.1907		-0.0021
		(0.2017)		(0.2078)
ln(age65)		0.2623**		0.2787*
		(0.1314)		(0.1516)
F-statistic	222.38	207.04	184.44	164.92
$p > \chi^2$	0.000	0.000	0.000	0.000
N	68	68	70	70

Notes: Standard errors are shown in parentheses. *** significant at the 1% level. ** significant at the 5% level. * significant at the 10% level. F-statistic and associated p-value measure overall goodness-of-fit of the model.

Table 7: Cross-country comparison of relative price of health care, health-related consumption, annual wage, and fraction of leisure: GE model

	p^m (PPP)		m (PPP, 2005 \$)		w (PPP, 2005 \$)		l (%)	
Country	**2005**	**2008**	**2005**	**2008**	**2005**	**2008**	**2005**	**2008**
Australia	0.95	0.92	4640	5333	30909	32386	78.0	77.9
Austria	0.99	1.07	5354	5302	31737	34177	79.6	79.1
Belgium	1.02	1.03	4900	4887	31288	32641	83.5	83.0
Canada	1.30	1.17	3823	4770	32363	33060	78.3	78.0
Cyprus	1.10	0.93	1346	1718	16536	17743	83.8	83.4
Czech Republic	0.80	0.79	2835	3062	19162	21812	76.9	76.2
Denmark	1.05	1.09	4559	4790	32117	33156	79.4	78.4
Estonia	0.78	0.75	1636	2385	15544	17744	77.3	76.2
Finland	1.14	1.02	3286	3893	29480	32118	79.9	79.2
France	1.11	0.96	4738	5533	28934	29751	83.7	83.5
Germany	0.94	0.92	5520	6067	29842	32647	82.6	82.0
Greece	0.85	0.82	4161	4794	23155	25017	78.3	77.0
Hungary	0.86	0.80	2592	2578	15799	16629	79.5	79.8
Iceland	1.16	1.06	4199	4660	33724	35003	74.8	74.0
Ireland	1.03	1.17	4153	4132	36420	37085	77.6	78.0
Israel	1.17	0.90	2481	3298	24050	26309	79.0	77.8
Italy	1.23	1.09	3060	3465	27305	27629	80.4	80.2
Japan	0.79	0.90	4769	4511	29369	30830	76.8	76.5
South Korea	0.52	0.66	3382	3258	20361	22495	73.2	74.2
Luxembourg	1.13	0.96	6783	7530	65153	68007	73.7	71.9
Malta	0.80	0.80	2868	3062	19372	20770	79.6	81.8
Mexico	1.00	0.94	1184	1339	12378	12901	77.0	77.0
Netherlands	0.94	0.95	5643	6816	33278	36224	82.1	81.4
New Zealand	1.09	0.98	3022	3805	24376	24041	77.2	77.7
Norway	1.24	1.26	4945	5294	46430	46791	81.2	79.9
Poland	0.69	0.92	1845	1801	12546	14760	81.3	79.5
Portugal	1.09	1.03	3012	3208	20319	21014	76.2	76.2
Slovak Republic	0.76	0.83	2241	2769	14498	18008	83.6	82.7
Slovenia	0.97	0.89	2859	3565	21384	24883	80.8	79.6
Spain	0.92	0.97	3720	3934	25501	26495	81.6	81.4
Sweden	1.16	1.07	3920	4534	32031	33486	79.7	79.1
Switzerland	0.78	0.73	7630	8393	34837	37154	76.3	75.8
Turkey	0.88	1.00	1089	1147	11124	11846	85.0	85.0
UK	1.05	1.00	4012	4590	31919	32893	80.6	80.8
US	1.20	1.20	8373	8804	40522	41051	78.9	79.0

Data source: OECD, World Bank and Conference Board Total Economy Database.

Notes: p^m is the relative price of health-related consumption in terms of non-medical consumption. m is the real annual health-related consumption per working age population. w is the real annualized wage per working age population. l is the fraction of leisure time in annual time endowment per working age population.

Table 8: Estimation results of equation 9: GE model

Variable	**FE**	**RE**	**MLE**	**Bootstrap**
$\ln(m/l)$	-0.9706*** (0.0978)	-1.1556*** (0.0737)	-1.1579*** (0.0811)	-1.1556*** (0.1091)
F-statistic	98.41	246.07	105.22	N/A
$p > \chi^2$	0.000	0.000	0.000	N/A
adjusted R^2	0.9872	N/A	N/A	N/A

Notes: N=70. Standard errors are shown in parentheses. *** significant at the 1% level. ** significant at the 5% level. * significant at the 10% level. F-statistic and associated p-value measure overall goodness-of-fit of the model.

Table 9: Estimates of equation 10: GE model

Model	**I**	**II**	**III**	**IV**	**V**	**VI**
Variable			Fixed effect			
ln(p/w)	-0.9149***	-0.8882***	-0.8386***	-.7460***	-0.8695***	-0.7444***
	(0.0919)	(0.0939)	(0.1082)	(0.0978)	(0.0908)	(0.1089)
ln(pub)	0.5005***				0.3617*	0.1749
	(0.1825)				(0.1879)	(0.2051)
ln(age65)		0.9732***			0.7187*	0.0101
		(0.3469)			(0.3587)	(0.5104)
ln(pop)			1.1241			0.2700
			(0.4843)			(0.5124)
ln(life)				5.4576***		4.2326
				(1.3354)		(2.5011)
F-statistic	62.41	63.09	58.25	80.28	46.74	30.58
$p > \chi^2$	0.000	0.000	0.000	0.000	0.000	0.000
adj R^2	0.9893	0.9894	0.9887	0.9913	0.9902	0.9908
Variable			Random effect			
ln(p/w)	-1.1003***	-1.0471***	-1.1670***	-0.9240***	-1.0334***	-0.9312***
	(0.0745)	(0.0742)	(0.0726)	(0.0825)	(0.0746)	(0.0807)
ln(pub)	0.2761*				0.1265	0.1018
	(0.1441)				(0.1453)	(0.1370)
ln(age65)		0.4128***			0.3816***	0.2827**
		(0.1198)			(0.1295)	(0.1234)
ln(pop)			0.0386*			0.0374
			(0.0205)			(0.0188)
ln(life)				3.9733***		2.7740***
				(0.9851)		(0.9918)
F-statistic	251.75	293.11	259.05	302.45	289.95	351.03
$p > \chi^2$	0.000	0.000	0.000	0.000	0.000	0.000

Notes: N=70. Standard errors are shown in parentheses. *** significant at the 1% level. ** significant at the 5% level. * significant at the 10% level. F-statistic and associated p-value measure overall goodness-of-fit of the model.

Table 10: Robustness check of estimation: GE model

Case	**Drop US**		**Per capita**	
Model	**Benchmark**	**Model V**	**Benchmark**	**Model V**
Variable	Fixed effect			
$ln(p^m/w)$	-.9701***	-0.8701***	-0.9648***	-0.8661***
	(0.0989)	(0.0922)	(0.0951)	(0.0888)
ln(pub)		0.3628*		0.3457*
		(0.1908)		(0.1873)
ln(age65)		0.7072*		0.7226*
		(0.3670)		(0.3574)
F-statistic	96.11	45.23	102.87	48.15
$p > \chi^2$	0.000	0.000	0.000	0.000
adj R^2	0.9861	0.9892	0.9871	0.9900
Variable	Random effect			
$ln(p^m/w)$	-1.1622***	-1.0194***	-1.1288***	-1.0094***
	(0.0693)	(0.0675)	(0.0727)	(0.0730)
ln(pub)		0.2720**		0.1226
		(0.1359)		(0.1442)
ln(age65)		0.3579***		0.3976***
		(0.1067)		(0.1294)
F-statistic	281.14	385.39	240.75	290.16
$p > \chi^2$	0.000	0.000	0.000	0.000
N	68	68	70	70

Notes: Standard errors are shown in parentheses. *** significant at the 1% level. ** significant at the 5% level. * significant at the 10% level. F-statistic and associated p-value measure overall goodness-of-fit of the model.