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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 we 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 may substantially reduce the nation's medical expenditure and help resolve its pressing fiscal uncertainty. Our study highlights the importance of several current nationwide campaigns aimed at improving national health status, from not only health but macroeconomic perspectives. Our study also provides a guidance to a growing macro-health literature 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 gauging 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 nationwide campaigns in the US, aimed at enhancing national health status.

The relatively low health status of Americans seems unsatisfactory given that health expenditure is much higher in the US than in those other countries. In 2010, for example, health expenditure-GDP ratio was 17.6% while health expenditure per capita (purchasing power parity (PPP), constant 2005 international $) was $8362 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 trajectory. 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 seemingly nonstopping trend has raised serious concerns nationwide, which took a center stage in health policy debates during the last two

[1] Data of life expectancy are taken from OECD Health Data 2012. The data are downloadable at http://stats.oecd.org/Index.aspx?DataSetCode=SHA.

[2] Data of health expenditure-GDP ratio are taken from OECD Health Data 2012. The data for Japan is for 1999. 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.

presidential campaigns.

The high and rapidly rising health expenditure has in fact 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 only 25.7% in 1980, but 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 the public, policymakers and 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 lies in the 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 spending 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 seems to be 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*

[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.

problem is insoluble. Simple, right? Impossible? We'd better hope not."[6]

In this paper, we point to a potential avenue that may help accomplish the two seemingly incompatible missions at the same time: one aimed at enhancing the nation's health status, while the other strived to reducing the nation's health expenditure, which, as illustrated above, seems to be key to resolving the nation's pressing fiscal uncertainty. We argue that the key is to promote health-enhancing leisure time, which, as we will show, may substantially reduce national health expenditure while maintaining national health status, and may thus provide a hopeful resolution to the long run deficit problem. The idea that health-enhancing leisure time is crucial for maintaining health was envisioned in the health economics literature (e.g., Grossman 1972, Ruhm 2000), while clinical, experimental, and empirical evidence in support of this idea can be found in the biomedical science, public health, psychobiology, and biosociology, and empirical health literature.[7] To this end, we develop a general equilibrium macroeconomic model that allows for a role of health-enhancing leisure time, in addition to medical care, in endogenous health accumulation. A key equilibrium condition arising from this structural model highlights a natural link between general macroeconomic conditions and optimal health investment portfolio. By fitting this condition to a cross-country panel data set, we can estimate the elasticity of substitution between the time and goods inputs in health production, which allows us to quantify the effect of increasing health-enhancing leisure time on reducing national health expenditure.[8]

[6]The quote is from Alan Blinder's 2013 book *After the Music Stopped: The Financial Crisis, the Response, and the Work Ahead*.

[7]Enormous biomedical, psychobiology, biosociology, and public health literature provide the independent evidence that health-enhancing leisure time, such as leisurely walking or cycling, exercising, vacationing, spending time in nature, engaging in social activities, having hobbies, proper sleep hygiene, and restorative activities, is a critical input for improving physical, mental, social, or cognitive health. See, among others, House, Landis, and Umberson (1988), Simon (1991), Ulrich et al. (1991), Haskell (1994), Benca and Quintas (1997), Staats, Gatersleben, and Hartig (1997), Szabo et al. (1998), Tominaga et al. (1998), Gump and Matthews (2000), Batty et al. (2003), Ryff, Singer, and Dienberg (2004), Sacker and Cable (2005), and Warburton, Nicol, and Bredin (2006). A comprehensive study by Pressman et al. (2009) find that a wide variety of leisure activities (e.g., having hobbies, exercising, socializing, visiting friends or family, and going on vacation, to name just a few) 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. Also see Caldwell and Smith (1988), Caldwell (2005), Russell (2009) and Payne et al. (2010) for an extensive review of the evidence. This fact has also been supported by empirical health literature. See Kenkel (1995), Sickles and Yazbeck (1998), Contoyannis and Jones (2004), and Insler (2011), among others.

[8]Some medical studies document the clinical and anecdotal evidence that increases in leisure time

The estimated elasticity is quantitatively significant, and this is so not only for our benchmark estimation based on the structural framework, but also for alternative econometric specifications, estimation methods, and data construction procedures. This implies that increasing health-enhancing leisure time can substantially reduce medical expenditure while maintaining health. Take year 2008 as an example: our benchmark estimation implies that, had Americans had one extra hour per day of health-enhancing leisure time, annual medical expenditure per working age person would have been \$1230 less (in constant 2005 international \$). This amounts to a \$251 billion (or 10.7%) reduction in national health expenditure. One way to increase health-enhancing leisure time is to decrease sedentary leisure activities such as "couch potato."[9] For example, had Americans devoted their 2.77 hours of daily TV watching time (American Time Use Survey 2008) to health-enhancing activities, national health expenditure would have been \$693 billion (or 29.5%) less than what it was. This saving in national health expenditure is sufficient to cover the US fiscal deficit in 2008! This illustrates how our proposed avenue can help slowing the seemingly inexorable growth of national health expenditure to "bend the cost curve." It does give us a hope to resolve the looming fiscal uncertainty.

Our study 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, Huang and Huffman 2013). Health production function is a key ingredient of these macro-health models with endogenous health accumulation. Our study sheds light on the importance of both leisure time and medical care for improving health and it provides the first empirical estimation of the elasticity of substitution between these two inputs in health production.

The paper is organized as follows. Section 2 describes the core ingredient of our general equilibrium framework, which lays out a groundwork for our empirical investigation of the relationship between leisure time and medical care in health production. Section 3 describes our construction of data. Section 4 presents our empirical estimations. Section 5 discusses some implications of our results. Section 6 concludes. Appendix A presents our full-fledged general equilibrium model and associated empirical results. Appendix B extends the general equilibrium model to further differentiate health-enhancing leisure time from health-neutral leisure time.

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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.

[9]Several current national campaigns such as "Let's Move!" are pushing exactly into this direction.

2 Key Ingredient of Structural Model

This paper develops a structural model to help empirically estimate the relationship between medical care and leisure time in health production, which, as argued above, serves as a key to bridging the two aforementioned national issues. At the heart of the model is an optimal health investment portfolio choice problem, which can be solved under given macroeconomic conditions specified by the other parts of the model. Since the key ingredient of the theoretical framework gives rise to the core estimation equation, for exposition purpose, we focus on the core ingredient and associated empirical estimates in this section, and relegate the description of the full-fledged general equilibrium model and associated estimation results to Appendix A.

Health investment in period t by a representative agent is created using the agent's health-related consumption (m_t) and leisure time (l_t) according to $H(m_t, l_t)$, which is a twice-differentiable, quasi-concave function increasing in both of its arguments. Taking as given the relative price of the health-related consumption goods (p_t) and the opportunity cost (shadow price) of leisure time (w_t), the agent solves the following cost-minimization problem,

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

As we will show in the full-blown model presented in the appendix, the shadow price of leisure time is determined in equilibrium by the marginal product of labor, which is equal to the wage rate for paid work time. The prices of the two inputs in health production are here measured in units of aggregate output in the economy. The first-order conditions for the cost-minimization problem give rise to

$$\frac{\partial H / \partial m_t}{\partial H / \partial l_t} = \frac{p_t}{w_t}. \tag{1}$$

This is to say that, optimal allocations of m_t and l_t must equate the marginal rate of technical substitution between the two inputs in health production with the ratio of their relative prices.

To allow flexibility of estimating the elasticity of substitution between leisure time and health-related consumption in maintaining health, we assume that the health production function is of the form of constant-elasticity-of-substitution (CES),

$$H(m_t, l_t) = (\theta m_t^{\xi} + (1-\theta) l_t^{\xi})^{\frac{1}{\xi}} \tag{2}$$

with some $\theta \in (0,1)$, where we note that $1/(1-\xi)$ corresponds to the elasticity of substitution between m and l. Given this specification of H, (1) is given by

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

Taking logarithm on both sides of the above equation, we have

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

This suggests a baseline empirical model of the following form

$$\ln y_t = \beta_0 + \beta_1 \ln x_t + \upsilon_t \tag{3}$$

where y_t denotes the ratio of health-related consumption to leisure time, x_t denotes the ratio of the relative price of health-related consumption goods to the wage rate, and υ_t is an error term. It is worth noting that, in equilibrium, the elasticity of technical substitution between the two inputs in health production coincides with the elasticity of their relative demand with respect to their relative price. This relative price elasticity of relative demand is given by $-\beta_1$ in our estimation equation (3).

3 Data

The construction of our data is guided by the general equilibrium model presented in Appendix A and its core ingredient laid out in Section 2. The sources of information that we use to construct the data are from OECD, World Bank, and Conference Board. The data constructed cover two years, 2005 and 2008. Our sample includes 35 countries for which a complete set of data can be constructed.[10]

3.1 Measurement of the Relative Price of Health Care

The measurement of the relative price of health-related consumption (p_t) is based on OECD data. To facilitate cross-country comparisons of the relative price of health care, we rely on the PPP-adjusted price index reported in OECD 2005 and 2008

[10] 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, the UK, and the US.

PPP Benchmark Results.[11] We use Table A2 in the OECD PPP Benchmark Results, which employs GK method to calculate PPP-based price levels for real expenditure, to obtain p_t for $t = 2005$ and 2008.[12] Column 19 in Table A2 reports PPP-adjusted price level of health care and column 1 in the table reports PPP-adjusted price level of GDP, while the latter is normalized to 100 for each country. Therefore, data in column 19 directly correspond to the relative price of health care p_t.

The second and third columns in Table 1 show the relative price of health-related consumption in the 35 countries for 2005 and 2008. According to the second column, for example, in 2005, the price of health care is 16% higher than that of GDP in the US, while in Germany the price of health care is only 95% of that of GDP. This implies that the relative price of health care is 21% higher in the US than in Germany in that year. In fact, as can be seen from the table, the US generally has a higher relative health care price than most of the countries in our sample.

3.2 Measurement of Health-Related Consumption

The measurement of health-related consumption (m_t) is based on data from World Bank. By definition, real medical expenditure at date t is the product of the relative price of health-related consumption p_t and the quantity of health-related consumption m_t. In other words, m_t is equal to real medical expenditure divided by p_t. We thus construct the quantity of health-related consumption m_t in the following way. First, we construct the data of real medical expenditure.[13] We obtain the data of health expenditure per capita (PPP, constant 2005 international $) from World De-

[11] OECD PPP Benchmark Results is a widely used data set 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] OECD uses two methods to calculate PPP-based price levels for real expenditure: EKS (Éltetö-Köves-Szulc) and GK (Geary-Khamis) methods. 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. 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, EKS method is not suitable for comparing relative price of individual expenditure categories across countries. In contrast, the real final expenditures in GK method are additive. Therefore, GK method is better suited to the analysis of price and volume structures across countries, such as the cross-country comparison of the relative price of health-related consumption to output. More details about the two methods can be found in the OECD Methodological Manual on Purchasing Power Parities.

[13] Notice that, since the measurement of p_t is PPP-based, and the health-related consumption m_t is a quantity measure, the data counterpart of real health expenditure has to be PPP-based as well.

velopment Indicators (WDI) of World Bank. It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health. We divide this variable by the share of population aged 15-64 (working age population) in total population (data taken from World Bank WDI) to transform it into the measures of health expenditure per working age person, to be consistent with the representative agent's setting in our theoretical framework. We then divide the measures by the data of p_t that are constructed in Section 3.1, to obtain the quantity of annual health-related consumption per working age person m_t. The fourth and fifth columns in Table 1 report the data of m_t for 2005 and 2008, respectively. Notice that the US has the largest "quantity" of health care among all countries in our sample.

3.3 Measurement of the Opportunity Cost of Leisure Time

In equilibrium, the opportunity cost of leisure time is determined by the marginal product of labor, or the wage rate for paid work time. Even though raw wage data are not directly available for all of the 35 countries in our sample, we can construct measures for marginal product of labor to proxy annualized wage, or, the shadow price of leisure, based on the general equilibrium theoretical framework presented in Appendix A. To begin, the first order condition for profit maximization under the Cobb-Douglas production function (equation (10) in Appendix A) implies the following familiar relation

$$w_t = (1-\alpha)\frac{g_t}{n_t} \tag{4}$$

where w_t denotes wage rate, g_t denotes output (GDP) per working age person, and n_t denotes hours worked per working age person. We follow (4) to construct the data of w_t as follows. First, consistent with the construction of p_t and m_t, we obtain the data of aggregate GDP (PPP, constant 2005 international $) from WDI. Second, we obtain the data on total annual hours worked from Conference Board Total Economy Database (TED). We also divide these measures by the working age population data obtained from World Bank to derive annual hours worked per working age person n_t.[14] Third, we set labor income share $(1-\alpha) = 0.64$, which is a commonly used value in the literature. We then divide aggregate GDP by total annual hours worked and multiply the number by 0.64 to obtain hourly wage. Finally, we multiply the hourly wage by the annual hours worked per working age person obtained in the second step to construct annualized wage. The sixth and seventh columns in Table 1 report

[14]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).

the data of w_t so constructed. We see significant variations across the 35 countries, in both 2005 and 2008, on annualized wage per working age person. In 2005, for example, Turkey had the lowest annualized wage of \$11124 whereas Luxembourg had the highest annualized wage of \$65153.

3.4 Measurement of Leisure Time

Leisure time is conventionally measured as the difference between time endowment and time spent on paid work (e.g., Rogerson 2006; Ohanian, Raffo, and Rogerson 2008; Jones and Klenow 2011). It is defined in the same spirit in our general equilibrium model presented in Appendix A, where time endowment of the representative agent is normalized to one in each period, which is devoted to either paid work (n_t) or leisure (l_t), as is illustrated by equation (9).

Notice that some leisure activities such as "couch potato" may not be health-enhancing. Hence, we could further divide total leisure time into health-enhancing leisure time (e.g., exercising, socializing, relaxing) and health-neutral leisure time, and consider a health production function that uses the health-enhancing leisure time and health-related consumption as inputs. Appendix B incorporates this feature to extend the general equilibrium model presented in Appendix A. The estimation equation (3) would then be modified by adding to the right hand side the log ratio of health-enhancing leisure time to total leisure time. The fraction of leisure time that is devoted to health-enhancing activity may be influenced by country-specific factors, such as culture, social norm, and life style, which arguably do not frequently change, at least not in such a short time as our sample. Indeed, according to American Time Use Survey, this fraction seems fairly stable during the time span in our sample.[15] As such, the estimation equation with the narrowly defined health-enhancing leisure time is just (3) augmented with a (time-invariant) country-specific factor – then β_1 would also measure the elasticity of substitution between health-related consumption and the narrowly defined health-enhancing leisure time[16] – this is exactly how we specify our benchmark empirical model (7) and our extended empirical model (8) below. Thus, although we make use of the conventionally defined leisure time to help simplify exposition, both our econometric models and estimation results would remain the same under the more sophisticated model setting.

We construct the leisure time l_t in the 35 countries as follows. First, we construct

[15] For example, according to ATUS, health-enhancing leisure activities such as "sports, exercise, and recreation" accounts for 0.32 hours daily time use in 2005. It is 0.33 hours in 2008. More broadly, "leisure and sports" accounts for 5.13 hours in 2005 and 5.18 hours in 2008.

[16] See Appendix B for a formal demonstration.

annual hours worked per working age person as in Section 3.3. We then divide the data by 365×16 to convert them into a fraction of total annual discretionary time. Leisure time l_t is equal to $1-$ fraction of annual hours worked per working age person. The eighth and ninth columns in Table 1 report the data of l_t. Again, we observe a significant variation across countries on the share of leisure time, from the lowest level of 73.2% in South Korea to the highest level of 85.0% in Turkey in 2005.

Table 2 provides the descriptive statistics of the dependent variable m/l and the independent variable p/w, as well as four controls, i.e., the share of public health expenditure in total health expenditure (pub), share of individuals aged 65 and above in total population (age65), total population (pop), and life expectancy (life), that are used in the extended empirical models later (see Section 4.3).[17]

Table 3 reports the correlations between the variables. The variables are measured in terms of their logarithms as they appear in the estimation equation (8) below. The dependent variable $\ln(m/l)$ is highly negatively correlated with the main explanatory variable $\ln(p/w)$. This reveals potential substitutability between health-related consumption and leisure time in health production.

4 Empirical Results

In this section, we describe our empirical models and report the estimation results.

4.1 Benchmark Empirical Model

In the context of the panel data constructed above, for country i and time t, the estimation equation (3) is given by

$$\ln(m/l)_{it} = \beta_0 + \beta_1 \ln(p/w)_{it} + v_{it}. \tag{5}$$

To capture country-specific factors that could have explanatory power on the dependent variable, we further define the disturbance term v_{it} as

$$v_{it} = \delta_i + u_{it} \tag{6}$$

where δ_i is meant to capture unobserved country-specific effects or unobserved heterogeneity, which may reflect, for instance, historical, cultural, social, or institutional

[17]The data for these control variables are taken from World Bank World Development Indicators (WDI).

differences across the 35 countries, while u_{it} is i.i.d. with respect to i and t. Substituting equation (6) into equation (5), we arrive at our optimization-based benchmark estimation equation:

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

Due to the lack of prior information regarding the correlation between the unobserved individual heterogeneity and independent variable $\ln(p/w)$, we consider both fixed effects (FE) and random effects (RE) for the estimation. F-test and Breusch-Pagan Lagrangian multiplier (LM) test are applied to fixed effects and random effects, respectively, and we apply Hausman test to help differentiate between the two models.[18] Given the potential caveat in using Hausman test to differentiate between FE and RE models, and the fact that our estimation results are virtually invariant and uniformly significant across FE and RE models, we in what follows will report both FE and RE results for each empirical specification.

4.2 Main Estimation Results

First, we treat equation (7) as a FE model.[19] In other words, we view that the unobserved country-specific individual effect δ_i is correlated with the regressor $\ln(p/w)$. The results of FE estimation of equation (7) 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 percent 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 percent. That implies the elasticity of substitution between health-related consumption m and leisure time l in health production is 1.3322.[20]

[18]Following the convention in the literature, we use 5% as a criterion to evaluate the significance of Hausman test results. If $Prob > \chi^2$ is less than 5%, we reject the null hypothesis of Hausman test and accept FE as the appropriate model. We are however aware that Hausman test might not be appropriate to test FE against RE. See Guggenberger (2010) for more details about the possible bias of Hausman test.

[19]The F test of equation (7) shows the p-value of 0.001 ($F(34, 34) = 2.922$, $Prob > F = 0.001$) which suggests that the fixed effect presents.

[20]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 surpasses 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.

Second, we run RE estimation of equation (7) assuming individual effect δ_i is unobserved and uncorrelated with the independent variable $\ln(p/w)$.[21] The results are reported in the third column of Table 4. In this case, β_1 is -1.3462 and it is again significant at 1% level. That implies the elasticity of substitution between m and l in health production is 1.3462.[22]

Since F-test and Breusch-Pagan Lagrangian multiplier (LM) test indicate the empirical significance of both FE and RE, to see whether FE or RE may be more appropriate for use in estimating equation (7), we run Hausman test. With $\chi^2 = 0.00$ and $Prob > \chi^2 = 0.9988$, Hausman test accepts 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 obtain maximum likelihood random-effects estimation of equation (7), which is a MLE that fully maximizes the likelihood of the RE model. We report the results in the fourth column of Table 4. The estimated β_1 is almost identical to that obtained in RE model.

Finally, we obtain the bootstrap estimation for the RE model of equation (7).[23] We report the results in the fifth column of Table 4. The estimated β_1 is identical to that obtained in RE model.

In summary, the estimation results of equation (7) are very robust and quite close to each other under different estimation approaches. The results suggest 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 Models and Results

The theoretical framework presented in Section 2 is a simple and highly stylized one, which is used to derive the core optimization-based estimation equation (7). It abstracts away from many factors that may affect health care and/or leisure time and hence our dependent variable in equation (7). To check whether or not our benchmark estimation results are sensitive to those abstractions and to further control

[21]We run Breusch and Pagan Lagrangian multiplier (LM) test for random effects to equation (7). With $\chi^2 = 8.40$ and $Prob > \chi^2 = 0.0019$, the test suggests that the individual effect is random.

[22]For both FE and RE estimations, the bootstrapped and robust standard errors have been checked for possible serial correlation in the error term of equation (7). In either case the estimated β_1 is virtually the same as the benchmark FE and RE estimation results.

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

the individual effects in the empirical model, we extend equation (7) by considering several alternative estimation equations in which we add, separately and jointly, four possible variables that might affect the dependent variable. 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 65 and above in total population (age65), total population (pop), and life expectancy (life), to be measured in their logarithms. Therefore, our empirical model is now extended to

$$\ln(m/l)_{it} = \alpha + X'_{it}\beta + \delta_i + u_{it} \tag{8}$$

where α is an intercept term, X is a vector of regressors, which include not only $\ln(p/w)$ but also some of the controls, δ_i represents an unobserved individual effect, and u_{it} is an error term. We are interested in the coefficient β_1 for the dependent variable $\ln(p/w)$. Both FE and RE results for each extended empirical model are reported in Table 5.

4.3.1 Share of public health expenditure (Model I)

We first add the share of public health expenditure in total health expenditure, ln(pub), into the right-hand side of equation (7) to capture differences in health care system across the countries in our sample. This share is generally higher in countries that adopt a universal health care system (e.g., the UK) than in countries that do not adopt a universal health care system (e.g., the US). For example, in 2005, this share was 81.9% in the UK, compared to 45.5% in the US. Notice that, as a proxy for health care system, pub may affect the dependent variable $\ln(m/l)$. A higher degree of government intervention in the health care system may on one hand imply more severe moral hazard problems that could increase the usage of health care,[24] while on the other hand impose more restrictions and rationing on health care that could decrease the usage of health care.[25] As Table 3 shows, the correlation between ln(pub) and the dependent variable $\ln(m/l)$ is positive (0.21). This suggests that the moral hazard effect on the demand side probably dominates the rationing effect on the supply side. In addition, a public health care system usually brings with it some price control on health care. This may explain why the correlation between ln(pub) and $\ln(p/w)$ is negative (-0.28), as reported in the table.

We obtain both FE and RE estimations to equation (8) with both $\ln(p/w)$ and ln(pub) as regressors. With $F = 5.26$ for F-test and $\chi^2 = 7.28$ for LM test, we

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

[25] Some anecdotal evidence on the rationing of health care in the UK can be found 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.

reject H_0 hypothesis for both cases at 1% significance level and find that both FE and RE are 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 (7). And it is significant at 1% level. The coefficient of ln(pub) is 1.9729 and it is significant at 1% level. This suggests that 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.

4.3.2 Share of age ≥ 65 (Model II)

In Model II, we control the share of individuals aged 65 and above in total population, ln(age65), in equation (8). Given that medical expenditures rise dramatically over the life cycle and especially after retirement (see Hagist and Kotlikoff 2009, Jung and Tran 2010, Halliday, He and Zhang 2012), and that leisure time jumps up after retirement, this share could potentially affect the m/l ratio. With $\ln(p/w)$ and ln(age65) as regressors, we obtain both FE and RE estimations to equation (8). With $F = 3.51$ in F-test for FE and $\chi^2 = 7.51$ in LM test for RE, we reject H_0 hypothesis for both cases and find that both FE and RE are significant. 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 (7). The coefficient of ln(age65) is 0.2473 and it is significant at 10% level.

4.3.3 Total population (Model III)

Population growth may affect the growth rate of medical care. In Model III, we add as an regressor the logarithm of total population, ln(pop), on top of $\ln(p/w)$, in estimating equation (8), to control the potential effect of population growth rate on medical expenditure. Both F-test and LM test reject the null hypothesis and find FE and RE exist. 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. As can be seen from Table 3, the correlation between ln(pop) and the dependent variable $\ln(m/l)$ is very low. Therefore, it is not surprising to see the estimated β_1 is -1.3478 at 1% significance level, very close to the estimate of β_1 obtained in the benchmark model (-1.3462). The coefficient of ln(pop) is 0.0045 and it is not statistically significant.

4.3.4 Life expectancy (Model IV)

In Model 4, we include, together with $\ln(p/w)$, the logarithm of life expectancy, ln(life), as a regressor, in estimating equation (8). Life expectancy could be a useful control for at least the following two reasons. First, life expectancy is a commonly used measure for health status (e.g., Bloom, Canning and Sevilla 2004); therefore including it as an additional regressor could help control cross-country differences in health status. Second, a longer life expectancy implies a greater share of individuals aged 65 and above in total population (as Table 3 illustrates, the correlation between ln(life) and ln(age65) is 0.41), which may lead to a greater usage of health care. As a corroborating evidence, Table 3 shows that ln(life) is highly positively correlated with the dependent variable $\ln(m/l)$. However, introducing ln(life) as an additional regressor may bring with it some multicollinearity problem. As Table 3 reveals, the correlation between ln(life) and the main regressor $\ln(p/w)$ is -0.65. Given the small sample size, this kind of correlation is likely to result in a multicollinearity problem. This may compromise the role of ln(life) as a control. Nevertheless, we obtain FE and RE estimations to equation (8) with both $\ln(p/w)$ and ln(life) as regressors. With $F = 3.51$ in F-test for FE and $\chi^2 = 7.51$ in LM test for RE, we find that both FE and RE are present. The results are shown 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 but only at 5% significance level. Compared to the other cases presented in Tables 4 and 5, the decrease in significance level of the estimated β_1 is another sign of the potential multicollinearity problem introduced by adding ln(life) as a regressor. Lastly, since ln(life) and $\ln(m/l)$ are highly positively correlated, it is not surprising to see the coefficient of ln(life) is 17.1427 at 1% significance level.

4.3.5 Model with pub and age65 (Model V)

The results presented above reveal that three out of the four controls, namely, ln(pub), ln(age65), and ln(life), have significant impacts on the dependent variable $\ln(m/l)$, though adding ln(life) introduces a potential multicollinearity problem; while the other control, namely, ln(pop), not only has a very low correlation with $\ln(m/l)$ and the other regressors, but the estimation of its coefficient is insignificant.[26] It is thus sensible to consider an extended empirical model with only ln(pub)

[26] It is worth noting that three out of the four controls, namely, ln(age65), ln(pop), and ln(life), may be subject to potential endogeneity problems. One source of endogeneity may come from some uncontrolled confounding variable, such as variation in health care technology, which could affect all these three variables. Variation in health care technology, however, does not bias the estimates of

and ln(age65) as controls. We therefore obtain estimations to equation (8) with three regressors, namely, $\ln(p/w)$, ln(pub), and ln(age65). F-test yields $F = 4.97$ with a p-value of 0.000 and LM test generates $\chi^2 = 4.91$ with $p = 0.0134$, indicating that both FE and RE exist. We report FE and RE estimation results in the sixth column in Table 5. Hausman test accepts FE as a more appropriate model at 1% significance level ($Prob > \chi^2 = 0.0004$). The RE results show that β_1 is -1.0377 and it is significant at 1% significance level. The coefficients of ln(pub) and ln(age65) are similar to those obtained in Model I and II.[27]

As can be seen from Tables 4 and 5, the estimations from the benchmark and extended empirical models suggest that the elasticity of substitution between health-related consumption and leisure time in health production is generally around, or, moderately above unit (1.3463), except in one case where there is a multicollinearity problem and the elasticity is moderately below unit (-0.6609). We have also considered other possible controls, but find that incorporating them into the benchmark or extended empirical models do not change the estimation results significantly.[28] We therefore consider [0.66,1.35] to be an empirically plausible range for the elasticity of substitution between the two primary inputs in health production.

the coefficient for $\ln(p/w)$, that is, β_1. To see this, we can extend the model in Section 2 to include a total factor productivity A_t in health production function, that is, we can change $H(m_t, l_t)$ to $A_t H(m_t, l_t)$. It can be shown that the first-order condition (1) will remain unchanged, and so will the benchmark estimation equation (3).

[27]We have also tried to include all the four controls together with $\ln(p/w)$ to check the robustness of the extended empirical model. FE estimation gives $\beta_1 = -0.7196$ while RE estimation shows $\beta_1 = -0.9837$, and both are significant at 1% significance level. Hausman test suggests to accept FE as a more appropriate model at 1% significance level.

[28]For instance, we have considered education level (edu), measured by gross school enrollment rate for tertiary education (data source: World Bank WDI), as another possible control, following the idea of Hall and Jones (2007) who suggest education as possibly relevant for health. When we add ln(edu) to the benchmark and various extended empirical models, the estimates of the coefficient for $\ln(p/w)$ are similar to those obtained in the models without ln(edu) included as an control. For example, when ln(edu) is incorporated into the benchmark model as a control, FE results show $\beta_1 = -1.1541$ and RE results show $\beta_1 = -1.3307$; when ln(edu) is added to Model V as an additional control, the estimate of β_1 is -0.9972 under FE and -1.2438 under RE; and, when ln(edu) is added to the extended model with all the four basic controls already included, the estimate of β_1 is -0.7087 under FE and -0.9811 under RE. In all these cases, Hausman test suggests RE as a more appropriate specification, and all these estimates of β_1 are significant at 1% level, though in almost all of these cases the estimate of the coefficient for ln(edu) is not statistically significantly.

4.4 Additional Robustness Checks

In this section we conduct additional robustness checks on our estimation results.

4.4.1 Controlling for income heterogeneity

Causal observation reveals that richer people may spend more on preventive health care and engage more in health-enhancing leisure activities. Indeed, as Doorslaer et al. (1997) show, income inequality is correlated with inequality in health status. The empirical literature surveyed by Kawachi and Kennedy (1999) and Subramanian and Kawachi (2004) actually suggests that income inequality could affect a society's general health status, which may influence its portfolio choice of health inputs.

It is thus sensible to check the robustness of our estimation results controlling for income heterogeneity. To do so, we use the Gini coefficient of income distribution, before tax and transfer, to proxy for income heterogeneity. Due to data availability, we tease out Cyrus, Malta, and Ireland from our sample, and base our analysis here on the remaining 32 countries.[29] Accordingly, we re-estimate equation (7) based on this sub-sample of countries: the estimate of β_1 is -1.5464 under FE and -1.4069 under RE; and, both estimates are significant at 1% level, while Hausman test suggests that RE is a more appropriate model. These results, as reported in Table 6, serve as a useful benchmark for our experiments to be conducted in this section.

Incorporating the logarithm of income Gini coefficient, ln(Gini), as an additional control variable into the five extended empirical models in sequel, we obtain the estimate of the coefficient β_1 for the main independent variable $\ln(p/w)$ as follows: it is -1.3272 under FE and -1.4184 under RE in Model I, -1.1303 under FE and -1.2944 under RE in Model II, -0.7697 under FE and -1.4440 under RE in Model III, -0.7724 under FE and -1.0134 under RE in Model IV, and -1.1242 under FE and -1.2950 under RE in Model V. All of these estimates are significant at 1% level and, in all of these cases, Hausman test suggests that FE is a more appropriate model. These results, as reported in Table 6, suggest that the empirical estimates of the elasticity of substitution between the two primary inputs in health production obtained in the previous sections are fairly robust when income heterogeneity is controlled for. An empirically plausible range for this elasticity is here from 0.77 to 1.41, very close to

[29] Our data on income Gini in 2005 for Spain, Switzerland, and Turkey are taken from, respectively, the 2005 Statistical Yearbook of Spain, Martinez (2010), and Inequality Watch (http://www.inequalitywatch.eu/spip.php?article58&id_groupe=8&id_mot=87). For the other 29 countries, our data are taken from OECD (http://stats.oecd.org/). Since OECD does not report income Gini for the individual year of 2005 or 2008, we use its reported income Gini for "mid-2000s" and for "late 2000s" to proxy for income Gini in these two years for those countries.

the one obtained before.[30]

4.4.2 Alternative sample selection and data construction methods

Our sample of countries includes the US as well as the 34 other countries for which we can construct a complete set of data that are needed for estimation of the empirical models derived from our structural framework. However, it is sometimes argued that the US may be an outlier on health care expenditure (e.g., Comanor et al. 2006, Pearson 2009). It is thus interesting to see how our estimation results may change when we tease out the US from the sample. In addition, and as is consistent with the structural model, our measurement of data is on the basis of per working age person. Yet, in many developed countries, it is not unusual for the elderly to spend a significant fraction of national health expenditure (e.g., Anderson and Hussey 2000). Therefore, it is also interesting to see what our estimation results may look like when the measurement of data is on per capita basis.

We report in Table 7 our findings from these two sets of robustness checks. Note that, while the table reports the estimation results under both FE and RE, in order to conserve space, only those results obtained from the benchmark model and one extended model, Model V, are reported in the table.

With the sample excluding the US, F-test and LM test reveal the existence of both FE and RE. Hausman test accepts RE in the benchmark model, but FE in the extended model (Model V), to be a more appropriate specification. In the former case the estimate of β_1 is -1.3082, while in the latter case it is -1.0391, both close to the estimates obtained using the full sample. It is clear that dropping the US out of the sample does not affect our estimation results significantly.

We reach a similar conclusion with the data measured on per capita basis: F-test and LM test suggest again the existence of both FE and RE; and, again, Hausman test accepts RE in the benchmark model, but FE in Model V, to be a more appropriate specification. In the former case the estimate of β_1 is -1.3202, while in the latter case it is -1.0117, both close to the estimates obtained when the data are measured on the basis of per working age person. It is thus clear that our estimation results do not change significantly under the alternative measure of data.

[30] It is conceivable that the elasticity of substitution between the two health inputs may differ across individuals at different income levels, since, for example, wealthier people may have more discretion in the portfolio choice of health inputs. To help capture some of such effect, we have also considered alternative specifications by adding an interaction term, $\ln(p/w) \times \ln(\text{Gini})$, into the various extended empirical models, but find that the estimated elasticity of substitution between the two health inputs are fairly similar to those reported in Table 6. These additional results are not reported here in order to conserve space, but are available upon request from the authors .

We have done more sensitivity or robustness checks than can be reported here, and found that our basic estimation results are generally quite robust. These results pinpoint the elasticity of substitution between health-related consumption and health-enhancing leisure time to being around, and most likely, modestly above, unit.

5 Some Implications

We can now use our empirical results to do some preliminary assessments on how increasing health-enhancing leisure time may help reduce health care expenditure. For the purpose of exposition, we set the elasticity of substitution between health-related consumption and health-enhancing leisure time to 1.35, as is consistent with our empirical estimations obtained in the previous sections. Our "back-of-envelope" calculation suggests that, even some moderate increase in health-enhancing leisure time may lead to a substantial reduction in national health expenditure, providing a hopeful resolution to the nation's looming fiscal uncertainty while at the same time maintaining national health status.

Take the year of 2008 as one example. In that year, working age Americans had on average 4614 leisure hours, which amounts to 79% of annual discretionary time. Had they had just one extra hour of health-enhancing leisure activity per day, their health-enhancing leisure time would have increased by *at least* 7.9%. This would have allowed a reduction in health care consumption by *at least* 10.7% ($1.35 \times 7.9\%$),[31] or, health care consumption per working age American would have decreased by *at least* $1070 (constant 2005 international $), from $9997 to $8927. Given the relative price of health care consumption of 1.15 for the US in that year, this is equivalent to a $1230 reduction in health expenditure per working age American, or, a $251 billion reduction in US national health expenditure.

This highlights the potential dual benefits of some recent national initiatives that urge Americans to move towards health-enhancing leisure activities, such as "sports, exercise, and recreation", and away from sedentary leisure activities, such as "couch potato": Such move shall not only help maintain Americans' health status, as already emphasized by those national campaigns, but also help reduce national health expenditure and thus provide one feasible resolution to the nation's looming

[31] A series of medical studies investigate the economic costs of inactivity and obesity based on micro data. Among others, Colditz (1999) assesses such costs of inactivity and obesity as resultant directly from treatment of morbidity and indirectly from lost productivity and forgone earnings due to premature mortality, and finds that the total costs account for about 9.4% of US national health expenditures. A subsequent study by Finkelstein et al. (2003) finds a similar figure, at 9.1%. See, also, Wang and Brown (2004).

fiscal uncertainty. While little attention has been paid so far to the latter benefit, this benefit can be quantitatively significant too, in light of our empirical investigation reported in the previous sections and the fact that an average American spends much more than one hour per day in sedentary activities. For example, according to American Time Use Survey (ATUS), in 2008, Americans on average spent 2.77 hours per day watching TV (80.9% of them watched TV everyday and these Americans on average watched about 3.43 hours per day). Had they devoted these 2.77 hours of TV watching time to health-enhancing activities, their health care consumption would have decreased by 29.5% ($1.35 \times 2.77 \times 7.9\%$), which amounts to a \$695 billion (constant 2005 international \$) reduction in national health expenditure.

To put this into a fiscal perspective, in 2008, US fiscal deficit accounted for 5.29% of its GDP, which amounts to \$693 billion (constant 2005 international \$). This is about the same amount of national health expenditure that could have been saved, and thus, the fiscal deficit could have been eliminated in its entirety, had Americans devoted their TV watching time in that year to health-enhancing activities. We thus conclude that, substituting health-enhancing leisure time for medical care is not only important for maintaining national health status, but an effective way to "bend the cost curve" to stop the seemingly inexorable rising trend in national health expenditure. It represents one feasible resolution to the long run fiscal uncertainty.

6 Conclusion

The United States is currently facing two pressing national issues: (1) How to improve its national health status which remains the lowest (even though its national health expenditure is the highest) among comparably rich countries; (2) How to avoid a long run fiscal collapse in the face of its rapidly rising government debt and looming fiscal uncertainty. We have pointed out a natural bridge between these two seemingly distinct issues. The key to this connection is leisure time. We have shown that increasing health-enhancing leisure time may substantially reduce national health expenditure while at the same time enhancing national health status, and as so, it may also provide a resolution to the long run fiscal uncertainty.

In arriving at this conclusion, we have developed a general equilibrium model of macro-health that allows for a role of health-enhancing leisure time, in addition to medical care, in endogenous health accumulation. A key equilibrium condition that arises from our structural model highlights a natural link between macroeconomic environment and optimal health investment portfolio. Fitting this condition to a cross-country panel data set, we have estimated the elasticity of substitution between the time and goods inputs in health production. This in turn has allowed us to quantify the effect of increasing health-enhancing leisure time on reducing national health expenditure. The effect has been found to be quantitatively large.

As significant as it already gets, the effect analyzed here captures only the direct effect coming out of the trade-off between health-enhancing leisure time and medical care in forming a health investment portfolio. Our analysis in this paper abstracts from potential indirect effects that substituting leisure time for medical care may bring with it, such as time saved from reduced visits to doctor's office. Taking into account these indirect effects is likely to make our results even more significant.

Our general equilibrium framework and structural estimation results presented in this paper should also provide a useful guidance to a growing macro-health literature with endogenous health accumulation, in which a health production function is a core ingredient. Our study demonstrates the importance of the time input in health production, a channel to which little attention has been paid by the existing macro-health literature.

7 Appendix A

The core ingredient of our macro-health model described in the main text concerns the production side of health. In this appendix, we present our full-fledged general equilibrium model, which includes also the consumption side of health. An identical estimation equation arises from this GE framework, with an added flexibility that the relative price of health-related consumption goods can now be measured not only in terms of the general price level of the economy, as in the main text, but also in units of non-medical consumption goods. This allows us to construct model-consistent measures of the relative price and quantity of health care using more direct and disaggregate information from the consumption side. Nevertheless, as we will show below, the estimation results coming out of this GE framework are strikingly similar to those obtained in the main text.

7.1 The General Equilibrium Model

Our model economy consists of a large number of identical agents, each endowed with one unit of discretionary time in every period, and a large number of perfectly competitive firms. A representative agent chooses the consumption of non-medical and medical commodities, accumulation of physical and health capitals, and time allocation between paid work and leisure, to maximize an expected lifetime utility,

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

subject to a budget constraint,

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

a law of motion for health capital,

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

and a time constraint,

$$1 = n_t + l_t, \tag{9}$$

for $t = 0, 1, 2, \ldots$, where c_t and m_t denote respectively non-medical and medical consumptions, k_{t+1} and h_{t+1} denote respectively physical and health capitals, n_t and l_t denote respectively times spent on paid work and leisure, p_t^m denotes the relative price of medical commodity, w_t and r_t denote respectively the wage rate on paid work and the rental rate on physical capital, δ_k and δ_h denote respectively the depreciation rates of physical and health capitals, and Π_t denotes firms' profit paid to the agent. The agent takes all prices and the initial stocks of physical and health capitals (k_0 and h_0) as given. The two functions U and H are twice-differentiable, quasi-concave, and monotonically increasing in their respective two arguments.

The notation $\pi(h^t)$ denotes the probability that the agent will survive up to date t. This survival probability is a monotonically increasing function of the history of the agent's health status $h^t \equiv (h_0, h_1, ...h_t)$. This is to capture the notion that better health can enhance the agent's life expectancy (Hall and Jones 2007). The agent values health not only because being healthier would allow her to live longer. Being healthier at any given date t would also make the agent feel better and even increase her marginal utility of non-medical consumption on that date, giving her some instantaneous satisfaction. This is why we have assumed that health stock h_t directly enters into period-t utility function. This is also meant to capture the so-called "consumption motive" for health investment emphasized by Grossman (1972).

A representative firm hires physical capital k_t^d and labor n_t^d to produce output g_t according to a Cobb-Douglas production function,

$$g_t = (k_t^d)^\alpha (n_t^d)^{1-\alpha}. \tag{10}$$

The firm's profit in period t is then given by

$$\Pi_t = (k_t^d)^\alpha (n_t^d)^{1-\alpha} - r_t k_t^d - w_t n_t^d.$$

A competitive equilibrium consists of an allocation $\{c_t, m_t, n_t, l_t, k_{t+1}, h_{t+1}\}$ for the agents, and an allocation $\{k_t^d, n_t^d\}$ for the firms, along with factor prices $\{w_t, r_t\}$, for all $t \geq 0$, such that: (i) Given factor prices and the 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 an agent's utility optimization problem for the given initial condition; (ii) Given factor prices, the allocation $\{k_t^d, n_t^d\}$ maximizes a firm's period-t profit; (iii) Markets clear, i.e., $c_t + p_t^m m_t + k_{t+1} - (1-\delta_k)k_t = g_t$, $k_t = k_t^d$, $n_t = n_t^d$.

Combining first order conditions for the utility and profit maximization problems, we can derive the following optimization condition,

$$\frac{\partial H/\partial m_t}{\partial H/\partial l_t} = \frac{p_t^m}{w_t}, \tag{11}$$

which is identical to the optimal allocation condition (1) obtained in the main text, and from which the same estimation equation as (3) arises when the health production function H takes the CES form specified in (2).

7.2 Data Construction

As can be seen from the previous section, in our general equilibrium setting, the relative price of health care can be measured not only in units of aggregate output, as in the main text, but also in units of non-medical goods. This allows us to construct model-consistent measures of the relative price and quantity of health care using more direct and disaggregate information from the consumption side. We describe below such construction in some detail.

7.2.1 Measurement of the relative price of health-related consumption

We construct the relative price of health care in 2005 and 2008 using the PPP-adjusted price index for real expenditure in individual consumption category reported in Table A2 of the OECD 2005 and 2008 PPP Benchmark Results. The construction takes three steps:

1. Column 19 of Table A2 reports PPP-adjusted price level of health care (let's denote it by p^h) and column 2 of the table reports PPP-adjusted price level of total individual consumption (let's denote it by p^{tc}). Dividing column 19 by column 2, we obtain the relative price of health care in terms of total individual consumption. Let's denote it by $p_{htc} \equiv p^h/p^{tc}$.

2. The PPP-based price level of total individual consumption is constructed by weighting the PPP-adjusted price levels of health care and non-medical goods by their respective shares in total nominal consumption expenditure. Denoting by p^c the PPP-adjusted price level of non-medical goods, and by $\tilde{m}$ and $\tilde{c}$ nominal medical and non-medical expenditures, respectively, we have

$$p^{tc} = \frac{\tilde{m}}{\tilde{m}+\tilde{c}} p^h + \frac{\tilde{c}}{\tilde{m}+\tilde{c}} p^c. \tag{12}$$

We construct the share of health expenditure in total consumption spending ($\tilde{m}/(\tilde{m}+\tilde{c})$) as follows. First, we obtain nominal GDP (let's denote it by $\tilde{g}$) and nominal total consumption expenditure ($\tilde{m}+\tilde{c}$) from OECD Stat.[32] Dividing the latter by the former gives us $(\tilde{m}+\tilde{c})/\tilde{g}$. We next obtain nominal medical expenditure-GDP ratio ($\tilde{m}/\tilde{g}$) from OECD Health data 2012. The share of health expenditure in total consumption is then $\tilde{m}/\tilde{g}$ divided by $(\tilde{m}+\tilde{c})/\tilde{g}$.

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

3. Noting the relative price of health care in terms of non-medical consumption is given by $p^m = p^h/p^c$, we can use (12) to construct p^m as follows:

$$p^m = \frac{\frac{\tilde{c}}{\tilde{m}+\tilde{c}}}{\frac{1}{p^{htc}} - \frac{\tilde{m}}{\tilde{m}+\tilde{c}}},$$

where p^{htc} is obtained from the first step above, and $\tilde{m}/(\tilde{m}+\tilde{c})$ and $\tilde{c}/(\tilde{m}+\tilde{c})$ are obtained from the second step above.

The second and third columns in Table 8 report the relative price of health care so constructed, for the 35 countries in our sample, for both the year of 2005 and the year of 2008. It is worth noting that this relative price of health care is higher in the US than in most of the countries in our sample.

7.2.2 Measurement of health-related consumption

We construct the quantity measure of health care (m_t) based on data from World Bank and OECD, in a way that is consistent with the construction of the relative price of health care (p^m) described above. This construction also takes three steps:

1. Data on actual individual consumption (PPP-based constant 2005 international $) are obtained from item 'transaction P_41' in OECD National Accounts of GDP (expenditure approach). This produces the measure 'VPVOB' in OECD Stat, which we denote by C_t.[33]

2. Multiplying C_t constructed above by the share of medical expenditure in total actual individual consumption ($\tilde{m}_t/(\tilde{m}_t+\tilde{c}_t)$) constructed in Section 7.2.1, we obtain PPP-based real health expenditure.

3. Total quantity of health-related consumption is given by the PPP-based real health expenditure constructed above divided by the relative price of health-related consumption (p_t^m) constructed in Section 7.2.1. This divided by working age population (data are taken from World Bank) gives rise to health-related consumption per working age person (m_t).

Table 8 reports the quantity of health care per working age person so constructed: the fourth and fifth columns of the table report the constructed data for 2005 and 2008, respectively. The data confirm, once again, that the US consumes the largest quantity of health care among all countries in our sample.

[33]OECD does not report data on actual individual consumption for Malta and Cyprus. For these two countries, we use data on household final consumption reported in World Bank's WDI (PPP-adjusted constant 2005 international $) to proxy actual individual consumption.

7.3 Empirical Results

Table 9 reports empirical results coming out of the benchmark estimation equation (7). Since F-test for FE ($F = 24.65$ with $p = 0.000$) and Breusch-Pagan Lagrange Multiplier (LM) test for RE ($\chi^2 = 27.70$ and $p = 0.000$) suggest that FE and RE are both present, we estimate the equation under both FE and RE and we report the results in the second and third columns of the table.[34] The estimated elasticity of substitution between health-related consumption and leisure time in health production is 0.97 and 1.1556, respectively. To check the robustness of the RE estimation, we obtain both MLE and bootstrap estimations under the RE specification. The estimated elasticity of substitution between health-related consumption and leisure time in health production is 1.1579 using the MLE approach and 1.1556 using the bootstrap approach, as shown in the fourth and fifth columns of the table. All of these estimations are statistically significant at the 1% level.[35]

Table 10 reports estimation results coming out of various versions of the extended empirical equation (8). Since F-test and LM test indicate the empirical significance of both FE and RE, the table reports estimations under both FE and RE specifications for each extended empirical model. As can be seen from the table, in all cases, the estimation of the elasticity of substitution between health care and leisure time is statistically significant at the 1% level and close to what is reported in the main text. Hausman test suggests FE as a more appropriate specification for Models I, III, IV, and V, but RE as a more appropriate specification for Model II, and the estimated elasticity of substitution between health care and leisure time in each of these cases is 0.9149, 0.8386, 0.7460, 0.8695, and 1.0471.[36]

Table 11 reports estimation results under both FE and RE specifications when we further control income heterogeneity in the benchmark model and Models I-V. As the table shows, in all cases, the estimation of the elasticity of substitution between health care and leisure time is statistically significant at the 1% level and the estimates are similarly clustered around unit as reported in the main text. Hausman test suggests FE as a more appropriate specification for Models I, II, III, and V, but

[34] Hausman test accepts FE as a more appropriate specification at 5% significance level ($Prob > \chi^2 = 0.0338$).

[35] Our estimation results do not change significantly when we drop Malta and Cyprus out of the sample (see Footnote 33): the estimated elasticity of substitution between health-related consumption and leisure time in health production is 0.9648 under the FE specification and 1.1423 under the RE specification, compared to 0.9706 and 1.1556 when the full sample of all the 35 countries is employed in the estimation.

[36] Similarly as in the main text, there is a potential multicollinearity problem in Model IV, the model in which ln(life) is included as a regressor in addition to $\ln(p^m/w)$, as the correlation between ln(life) and $\ln(p^m/w)$ is -0.6418.

RE as a more appropriate specification for the benchmark model as well as Model IV, and the estimated elasticity of substitution between health care and leisure time in each of these cases is 0.8637, 0.8501, 0.7123, 0.8273, 1.1530, and 0.8873.

We have also obtained similar empirical results as in the main text when the US is dropped out of our sample, and when data are measured on per capita basis. To conserve space, Table 12 reports only the estimation results for the benchmark model and Model V (under both FE and RE specifications). As can be seen from the table, in all cases, the estimation of the elasticity of substitution between health care and leisure time is statistically significant at the 1% level and the estimates are tightly clustered around unit. Hausman test suggests FE as a more appropriate specification for the benchmark model, and the estimated elasticity of substitution between health care and leisure time is 0.9701 for the case that the US is dropped out of our sample and 0.9649 for the case in which data are measured on per capita basis. For Model V, Hausman test suggests RE as a more appropriate specification, and the estimated elasticity of substitution between health care and leisure time is 1.0194 for the case that the US is dropped out of our sample and 1.0094 for the case in which data are measured on per capita basis.

To summarize the results reported in this appendix, our general-equilibrium based estimation of the elasticity of substitution between health care and leisure time is similarly and somewhat even more closely centered around unit, compared to what is reported in the main text.

8 Appendix B

In the general equilibrium model presented in Appendix A, total time endowment is distributed between paid work and leisure time, the latter of which is in its entirety health enhancing. In actuality, some leisure activities such as "couch potato" may not be health enhancing. In this appendix, we extend the model to divide leisure time into health-enhancing leisure time (e.g., time spent in exercising, socializing, relaxing, etc.) and health-neutral leisure time, and consider a health production function that uses this (narrowly defined) health-enhancing leisure time and health-related consumption as inputs. We show, under an empirically justifiable assumption, that this extended theoretical model produces the same empirical estimation equations as (7) and (8), where β_1 measures also the elasticity of substitution between the narrowly defined health-enhancing leisure time and health-related consumption. This is to say that, both our econometric models and estimation results reported above would remain unchanged in the extended model.

To put this into notation, let's denote by l^g health-enhancing leisure time and l^n

health-neutral leisure time, and assume that the former enters into health production function but not utility function, while the latter enters into utility function but not health production function.[37] The utility-maximization problem for a representative agent is then given by

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

subject to

$$\begin{aligned} c_t + p_t^m m_t + k_{t+1} &= w_t n_t + (r_t + 1 - \delta_k) k_t + \Pi_t, \\ h_{t+1} &= (1 - \delta_h) h_t + H(m_t, l_t^g), \\ 1 &= n_t + l_t^g + l_t^n. \end{aligned}$$

The first-order conditions for this utility-maximization problem are

$$\frac{\partial U}{\partial c_t} = \beta \frac{\pi(h^{t+1})}{\pi(h^t)} \frac{\partial U}{\partial c_{t+1}} \left(r_{t+1} + 1 - \delta_k \right), \tag{13}$$

$$\frac{\partial H / \partial l_t^g}{\partial H / \partial m_t} p_t^m = \frac{\partial U / \partial l_t^n}{\partial U / \partial c_t}, \tag{14}$$

$$\frac{\partial H / \partial m_t}{\partial H / \partial l_t^g} = \frac{p_t^m}{w_t}, \tag{15}$$

$$\frac{\partial U}{\partial c_t} = \beta \frac{\partial H / \partial m_t}{p_t^m} \frac{\pi(h^{t+1})}{\pi(h^t)} \cdot \left\{ \frac{\partial U}{\partial h_{t+1}} + \frac{\partial \pi(h^{t+1}) / \pi(h^{t+1})}{\partial h_{t+1}} U_{t+1} + \frac{\partial U / \partial c_{t+1}}{\partial H / \partial m_{t+1}} p_{t+1}^m (1 - \delta_h) \right\} \tag{16}$$

where (13) is a combination of the Euler equation for physical capital accumulation and the intertemporal trade-off condition for non-medical consumption, (14) is the intratemporal trade-off condition equating the return on health-enhancing leisure time to that on health-neutral leisure time, (15) is the intratemporal trade-off condition governing an optimal health investment portfolio, and (16) is the Euler equation for health capital accumulation.

Assuming the health production function H takes the CES form specified in (2), we can write (15) for country i at date t as

$$\left(\frac{m_{it}}{l_{it}^g} \right)^{\xi - 1} = \frac{1 - \theta}{\theta} \frac{p_{it}^m}{w_{it}}, \tag{17}$$

[37] If l^g also enters into utility function, in the same way as does l^n, then an agent would strictly prefer l^g to l^n, and the model would collapse into the one presented in Appendix A.

where $1/(1-\xi)$ corresponds to the elasticity of substitution between health-related consumption and health-enhancing leisure time. Under the assumption that health-enhancing leisure time accounts for a stable fraction of total leisure time for each given country (i.e., $l_{it}^g = \psi_i l_{it}$ for some $\psi_i > 0$),[38] equation (17) reduces to

$$\left(\frac{m_{it}}{\psi_i l_{it}}\right)^{\xi-1} = \frac{1-\theta}{\theta}\frac{p_{it}^m}{w_{it}}.$$

Taking logarithm on both sides, we have

$$\ln\frac{m_{it}}{l_{it}} = \frac{1}{\xi-1}\ln\frac{1-\theta}{\theta} + \frac{1}{\xi-1}\ln\frac{p_{it}^m}{w_{it}} + \ln(\psi_i),$$

which gives rise to the empirical equation (7) or (8) in the main text.

To conclude, although we make use of the conventionally defined leisure time to help simplify presentation in the main text, both our econometric models and estimation results would remain unchanged under the more sophisticated model setting that differentiates health-enhancing leisure time from health-neutral leisure time.

[38] See Section 3.4, especially Footnote 15, which provides some empirical evidence that, although the fraction of leisure time that is devoted to health-enhancing activity may be influenced by country-specific factors, such as culture, social norm, and life style, it does not frequently change in a given country in such a short time period as that covered by our sample.

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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

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

Note: 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 person. w is the real annualized wage per working age person. l is the fraction of leisure time in annual time endowment per working age person.

Table 2: Summary statistics

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
age≥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

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

Table 3: Correlation matrix

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

Source: OECD, World Bank and Conference Board Total Economy Database.
Note: pub is the share of public health expenditure in total health expenditure. age65 is the share of individuals aged 65 and above in total population. pop is total population. life is life expectancy at birth for total population.

Table 4: Estimation results for benchmark empirical model

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

Note: N=70. Standard errors are shown in parentheses. *** significant at the 1 percent level. ** significant at the 5 percent level. * significant at the 10 percent level. F-statistic and associated p-value measure overall goodness-of-fit of the model. Bold numbers are the results suggested by Hausman test.

Table 5: Estimation results for extended empirical models

Model	**I**	**II**	**III**	**IV**	**V**
Variable			Fixed Effect		
$\ln(p/w)$	**-1.1573*****	-1.0642***	-0.9727***	**-0.6609****	**-1.0377*****
	(0.2477)	(0.2952)	(0.3080)	(0.2485)	(0.2501)
ln(pub)	1.9729***				1.6722***
	(0.4240)				(0.4463)
ln(age65)		2.7527***			1.5021*
		(0.9395)			(0.8626)
ln(pop)			3.4241***		
			(1.1877)		
ln(life)				17.1427***	
				(2.9235)	
F-statistic	25.62	15.55	15.34	35.43	19.15
$p > \chi^2$	0.000	0.000	0.000	0.000	0.000
adj R^2	0.9378	0.9182	0.9177	0.9495	0.9414
Variable			Random effect		
$\ln(p/w)$	-1.3245***	**-1.2433*****	**-1.3478*****	-1.0422***	-1.2417***
	(0.1099)	(0.1099)	(0.1009)	(0.1264)	(0.1169)
ln(pub)	0.1407				-0.0200
	(0.1954)				(0.2042)
ln(age65)		0.2473*			0.2630*
		(0.1276)			(0.1481)
ln(pop)			0.0045		
			(0.0202)		
ln(life)				4.8652***	
				(1.2682)	
F-statistic	161.82	199.09	179.16	200.65	176.16
$p > \chi^2$	0.000	0.000	0.000	0.000	0.000

Note: N=70. Standard errors are shown in parentheses. *** significant at the 1 percent level. ** significant at the 5 percent level. * significant at the 10 percent level. F-statistic and associated p-value measure overall goodness-of-fit of the model. Bold numbers are the results suggested by Hausman test.

Table 6: Estimation results when controlling income Gini

Model	**Benchmark**	**I**	**II**	**III**	**IV**	**V**
Variable			Fixed effect			
ln(p/w)	-1.5464***	**-1.3272*****	**-1.1303*****	**-0.7697*****	**-0.7724*****	**-1.1242*****
	(0.2532)	(0.2277)	(0.2148)	(0.2399)	(0.1587)	(0.2017)
ln(pub)		1.3749***				0.8032**
		(0.3835)				(0.3643)
ln(age65)			2.9745***			2.3190***
			(0.6306)			(0.6628)
ln(pop)				4.6635***		
				(0.9233)		
ln(life)					15.5988***	
					(1.7379)	
ln(Gini)		-0.5608	-0.7655*	-1.2492***	-0.3790	-0.7169*
		(0.4628)	(0.4202)	(0.4272)	(0.2868)	(0.3954)
F-statistic	37.30	22.18	29.34	31.82	73.72	26.15
$p > \chi^2$	0.000	0.000	0.000	0.000	0.000	0.000
adj R^2	0.9430	0.9593	0.9667	0.9687	0.9844	0.9706
Variable			Random effect			
ln(p/w)	**-1.4069*****	-1.4184***	-1.2944***	-1.4440***	-1.0134***	-1.2950***
	(0.0932)	(0.1064)	(0.1273)	(0.1112)	(0.1358)	(0.1295)
ln(pub)		0.1255				0.0291
		(0.2005)				(0.2292)
ln(age65)			0.2832*			0.2770*
			(0.1454)			(0.1641)
ln(pop)				0.0287		
				(0.0244)		
ln(life)					6.4724***	
					(1.3029)	
ln(Gini)		0.1544	-0.1161	0.0247	-0.1120	-0.1183
		(0.3098)	(0.3285)	(0.3210)	(0.2876)	(0.3345)
F-statistic	227.68	203.42	200.46	185.93	225.07	195.38
$p > \chi^2$	0.000	0.000	0.000	0.000	0.000	0.000

Note: N=64. Standard errors are shown in parentheses. *** significant at the 1 percent level. ** significant at the 5 percent level. * significant at the 10 percent level. F-statistic and associated p-value measure overall goodness-of-fit of the model. Bold numbers are the results suggested by Hausman test.

Table 7: Robustness check

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

Note: Standard errors are shown in parentheses. *** significant at the 1 percent level. ** significant at the 5 percent level. * significant at the 10 percent level. F-statistic and associated p-value measure overall goodness-of-fit of the model. Bold numbers are the results suggested by Hausman test.

Table 8: Cross-country comparison of relative price of health care, health-related consumption, annual wage, and fraction of leisure: GE framework

	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

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

Note: 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 person. w is the real annualized wage per working age person. l is the fraction of leisure time in annual time endowment per working age person.

Table 9: Estimation results for benchmark empirical model: GE framework

Variable	**FE**	**RE**	**MLE**	**Bootstrap**
$\ln(m/l)$	**-0.9706*****	-1.1556***	-1.1579***	-1.1556***
	(0.0978)	(0.0737)	(0.0811)	(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

Note: N=70. Standard errors are shown in parentheses. *** significant at the 1 percent level. ** significant at the 5 percent level. * significant at the 10 percent level. F-statistic and associated p-value measure overall goodness-of-fit of the model. Bold numbers are the results suggested by Hausman test.

Table 10: Estimation results for extended empirical models: GE framework

Model	**I**	**II**	**III**	**IV**	**V**
Variable			Fixed effect		
$\ln(p/w)$	**-0.9149*****	-0.8882***	**-0.8386*****	**-.7460*****	**-0.8695*****
	(0.0919)	(0.0939)	(0.1082)	(0.0978)	(0.0908)
ln(pub)	0.5005***				0.3617*
	(0.1825)				(0.1879)
ln(age65)		0.9732***			0.7187*
		(0.3469)			(0.3587)
ln(pop)			1.1241		
			(0.4843)		
ln(life)				5.4576***	
				(1.3354)	
F-statistic	62.41	63.09	58.25	80.28	46.74
$p > \chi^2$	0.000	0.000	0.000	0.000	0.000
adj R^2	0.9893	0.9894	0.9887	0.9913	0.9902
Variable			Random effect		
$\ln(p/w)$	-1.1003***	**-1.0471*****	-1.1670***	-0.9240***	-1.0334***
	(0.0745)	(0.0742)	(0.0726)	(0.0825)	(0.0746)
ln(pub)	0.2761*				0.1265
	(0.1441)				(0.1453)
ln(age65)		0.4128***			0.3816***
		(0.1198)			(0.1295)
ln(pop)			0.0386*		
			(0.0205)		
ln(life)				3.9733***	
				(0.9851)	
F-statistic	251.75	293.11	259.05	302.45	289.95
$p > \chi^2$	0.000	0.000	0.000	0.000	0.000

Note: N=70. Standard errors are shown in parentheses. *** significant at the 1 percent level. ** significant at the 5 percent level. * significant at the 10 percent level. F-statistic and associated p-value measure overall goodness-of-fit of the model. Bold numbers are the results suggested by Hausman test.

Table 11: Estimation results when controlling income Gini: GE framework

Model	**Benchmark**	**I**	**II**	**III**	**IV**	**V**
Variable			Fixed effect			
ln(p/w)	-0.9812***	**-0.8637*****	**-0.8501*****	**-0.7123*****	-0.6978***	**-0.8273*****
	(0.1068)	(0.0990)	(0.1033)	(0.1284)	(0.1112)	(0.0980)
ln(pub)		0.6075***				0.4502**
		(0.1949)				(0.2093)
ln(age65)			0.9887***			0.6421*
			(0.3545)			(0.3710)
ln(pop)				1.5825***		
				(0.5776)		
ln(life)					5.3332***	
					(1.4243)	
ln(Gini)		-0.3912	-0.4374*	-0.6195**	-0.3329	-0.4241*
		(0.2305)	(0.2373)	(0.2525)	(0.2191)	(0.2238)
F-statistic	84.46	41.84	39.27	38.90	47.57	34.29
$p > \chi^2$	0.000	0.000	0.000	0.000	0.000	0.000
adj R^2	0.9861	0.9896	0.9890	0.9889	0.9906	0.9903
Variable			Random effect			
ln(p/w)	**-1.1530*****	-1.0999***	-1.0070***	-1.1417***	**-0.8873*****	-1.0067***
	(0.0771)	(0.0831)	(0.0844)	(0.0821)	(0.0921)	(0.0851)
ln(pub)		0.2245				0.0233
		(0.1653)				(0.1681)
ln(age65)			0.4183*			0.4110***
			(0.1264)			(0.1376)
ln(pop)				0.0275		
				(0.0241)		
ln(life)					4.1334***	
					(1.0089)	
ln(Gini)		0.1061	-0.2574	-0.1097	-0.1085	-0.2553
		(0.2235)	(0.2159)	(0.2273)	(0.1994)	(0.2182)
F-statistic	223.57	218.02	260.86	217.86	283.18	256.64
$p > \chi^2$	0.000	0.000	0.000	0.000	0.000	0.000

Note: N=64. Standard errors are shown in parentheses. *** significant at the 1 percent level. ** significant at the 5 percent level. * significant at the 10 percent level. F-statistic and associated p-value measure overall goodness-of-fit of the model. Bold numbers are the results suggested by Hausman test.

Table 12: Robustness check: GE framework

Case	**Drop US**		**Per capita**	
Model	**Benchmark**	**Model V**	**Benchmark**	**Model V**
Variable		Fixed effect		
$ln(p^m/w)$	**-0.9701*****	-0.8701***	**-0.9649*****	-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

Note: Standard errors are shown in parentheses. *** significant at the 1 percent level. ** significant at the 5 percent level. * significant at the 10 percent level. F-statistic and associated p-value measure overall goodness-of-fit of the model. Bold numbers are the results suggested by Hausman test.

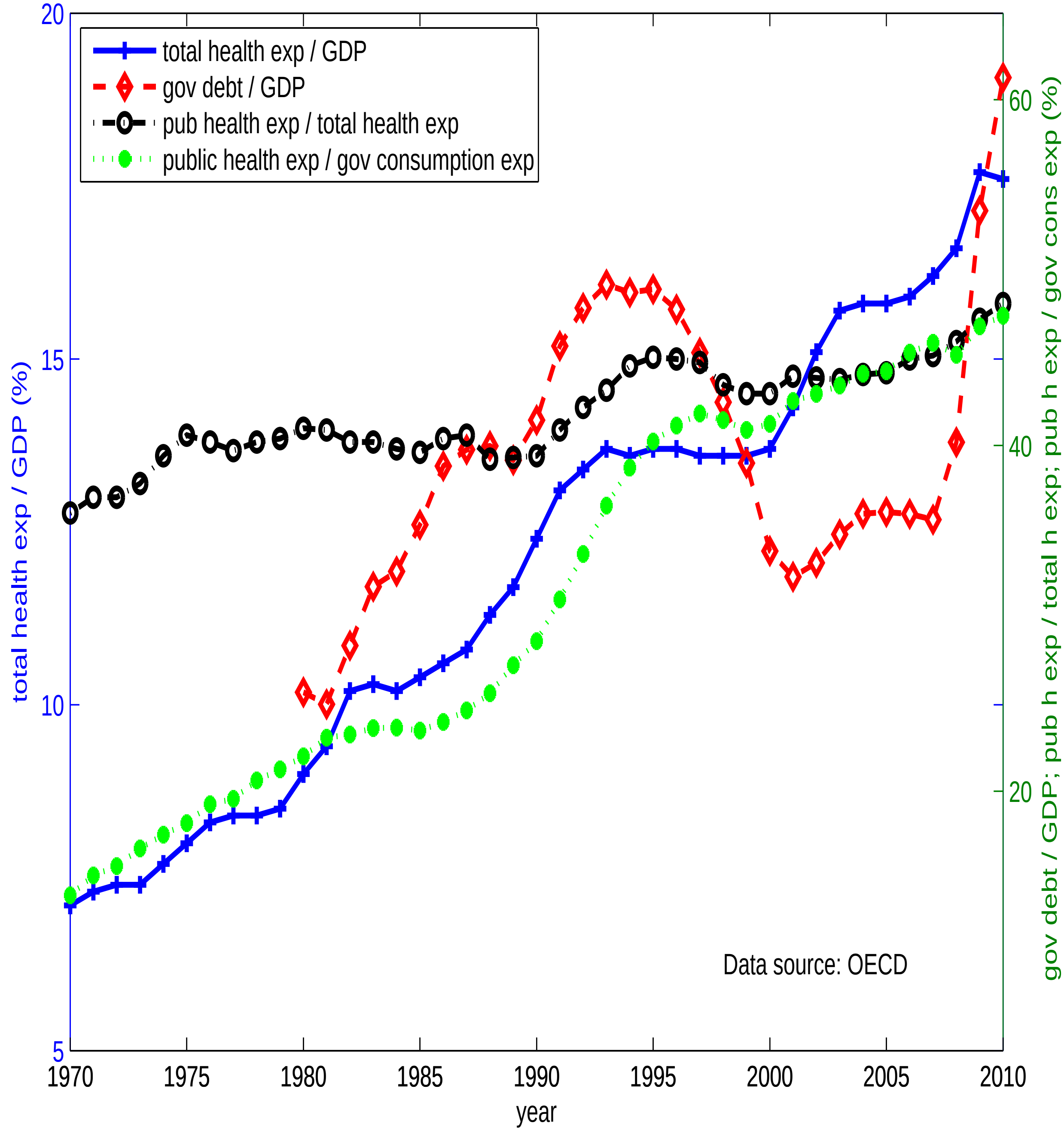

Figure 1. Total health expenditure, public health expenditure and federal government debt in the US

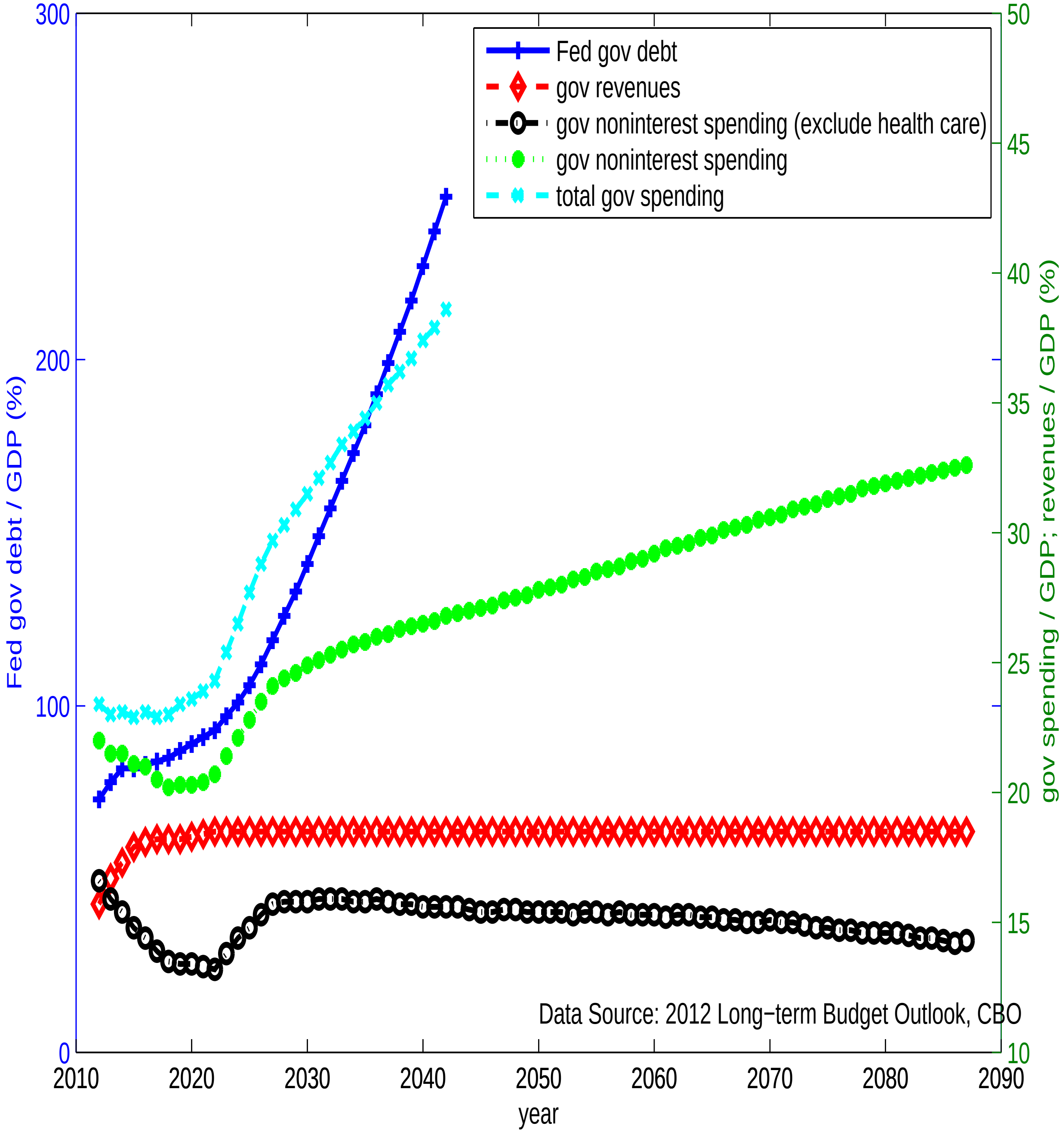

Figure 2. The long-term projections of US federal government spending, revenue and debt as a share of GDP