On Optimal Taxation and Subsidization of Health Goods

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Abstract

In the current US health insurance system in which the households directly sponsor small part (10%) of the high health care cost they incur (17.7% of GDP), optimal taxation and subsidization on health goods show large scope for welfare improvement. If households do not fully pay for the medical expenditure, they generate externalities by not internalizing the full effects of their own health behaviors on medical expenditure and, in turn, on health insurance premiums or tax burdens for governmental health care subsidies. Using an overlapping generations framework of working age that models these externalities, this paper compares the welfare effects of optimal taxation of alcohol and cigarette to those of optimal subsidization of complementary goods to physical activity. Nation-wide sports goods subsidization policies, as opposed to the extant health excise taxes on alcohol and cigarette, have received less attention despite the numerous evidences of their potentials to internalize the externalities. The welfare gain from optimal subsidization of sports goods, however, is $146.08 per household every year, about 16 times higher than that from optimal taxation on alcohol and cigarette. The former decreases the aggregate medical expenditure by 3.2%, while the latter only by 0.2%.

JEL Codes: H21, H23, H51, I12, I13, I14
Keywords: Optimal Taxation, Health Capital, Externality, Excise Tax, Sports Goods Subsidization, Medical Expenditure, Health Care, Health Insurance, Health Inequality.

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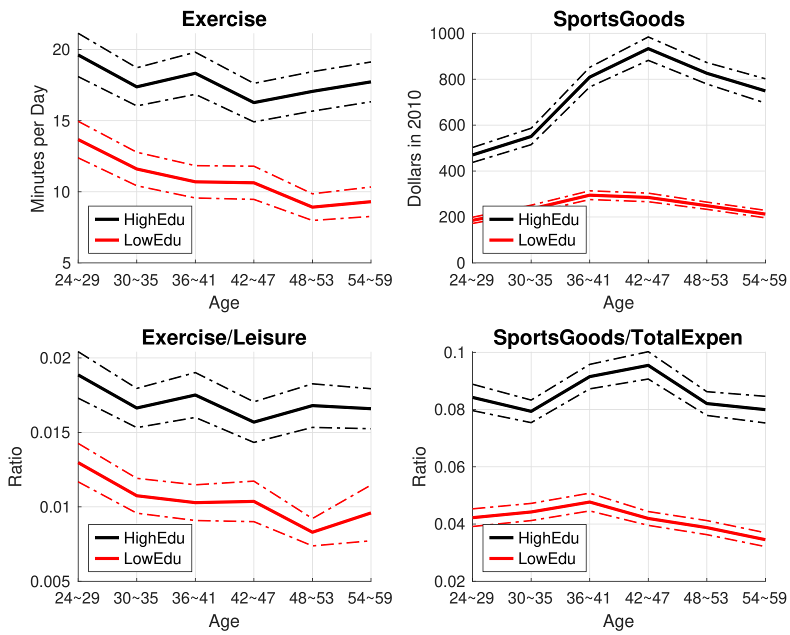
1 Introduction

It has been a growing interest of the US government to enhance the aggregate health and reduce the increasing burden of medical expenditure, as it has reached \$3.6 trillion in 2018, 17.7% of GDP, and governments has subsidized 45% of it, according to National Health Expenditure Data (NHE). Among many policies to target these, excise taxes on alcohol and cigarette are often priorly mentioned, due to their long histories and well known health effects. According to Centers for Disease Control and Prevention (CDC), cigarette is related to coronary heart disease, stroke, and lung caner, and smoking causes 480,000 deaths in the US each year (1 in 5 deaths). Alcohol is also related to numerous long term diseases such as high blood pressure, heart disease, stroke, liver disease, and cancer. In 2011 - 2015, excessive drinking was responsible for 1 in 10 deaths among working age population, although many of them are from causes other than health problems such as car accidents and impulsive behaviors.

Exercise or sports goods subsidization, on the other hand, have just started receiving spot light in the health economics literature. For example, Charness and Gneezy (2009) find scope for financial intervention in habit formation of physical activity and health improvement. Sturm (2002) also reports that obesity is associated with 15 percentage points higher increase in inpatient and outpatient spending and with 49 percentage points higher increase in medications than smoking, and that there is no important effect of alcohol usage on health care cost. Despite the increasing evidence of positive effects of sports goods subsidization on health, both absolutely and relatively to alcohol and cigarette taxation, there is no nation-wide policy subsidizing sports goods subsidy until today.

We plot Figure 1 as a supportive evidence of the potential of sports goods subsidy to enhance national health, using American Time Use Survey (ATUS) and Consumer Expenditure Survey (CEX) 2005 ~ 2017. The first row panels show that high education population spends more time on exercising and consumes more sports goods than the low education group, and the second row shows that these are not simply due to income or leisure time difference. Figure 1 is suggestive of complementarity between these two variables and of possible increase in exercise from subsidizing sports goods, eventually improving aggregate health and reducing medical expenditure. This paper investigates the possibly underrated potential of sports goods subsidization in fulfilling the health purposes that the current tax system is targeting.

Figure 1: Exercise and Sports Goods : High VS Low Education



We focus on two channels of medical expenditure related externality that justify positive taxation or subsidization : the insurance burden externality and the tax burden externality (we jointly call them "medical expenditure burden externality" in this paper). Firstly, Table 1 suggests an existence of externality from the US health insurance system. Using Medical Expenditure Panel Survey (MEPS) 2005 ~ 2017 of working age (24 ~ 59) population, we regress the out-of-pocket medical expenditure on total medical expenditure. Out of a marginal dollar of medical expenditure incurred, only 3 cents on average is directly charged on the households, and the rest is covered in lump-sum by other sources[1]. Despite the positive effects of health insurance system alleviating losses from negative health shocks, this suggests a possibility that a large part of health production is not optimally internalized into households' problems. The households' non-internalized effects of health behaviors on insurance premium could result in the premium and deductible higher than the optimum.[2]

Secondly, improving the aggregate health could relax the distortionary tax burden of subsidizing medical expenditure. By reducing the total medical expenditure and relaxing the tax burden, accepting that every real form of tax distorts the optimal relative price system, we see margins of Pareto improvement because the government

[1]NHE reports only 10% of the total medical expenditure is covered by out-of-pocket source.
[2]This is sometimes called 'Moral Hazard' in the macroeconomics literature

Table 1: Out-of-pocket Expenditure Rate

	Dependent variable:
	Out-of-pocket Expense
Total Medical Expense	0.033*** (0.0004)
Constant	672.641*** (7.016)
Observations	90,319
R^2	0.087
Note:	*p<0.1; **p<0.05; ***p<0.01

budget constraint is not internalized in the household's problem in the first place. The non-internalized effect of health behaviors on tax burden could eventually raise the sales tax rate higher than the optimum, and the taxation or subsidization on health related goods could partially resolve this externality. This paper is mainly interested in targeting these two channels of medical expenditure related externality. We abstract from any externality in forms of direct damage on other people's health, such as drink driving accident and second-hand smoking.[3] We also abstract from externality induced by time-inconsistent preference and focus on that related to medical expenditure burden.[4]

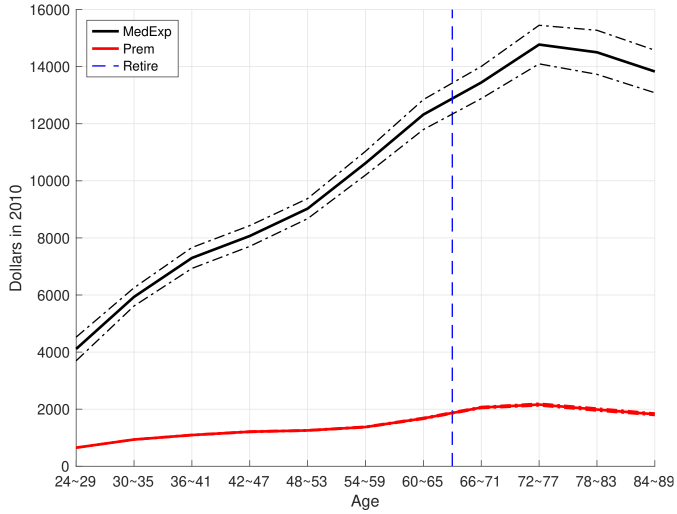
Concerning the two forms of externality, the medical expenditure of retirement could play an important role. We use MEPS and CEX to plot Figure 2, which shows that the absolute gap between the incurred medical expenditure and premium is higher in retirement than working age. This suggests a possibility that non-internalized effects of working age health behaviors on retirement medical expenditure could be as important as within working age externality. Households in working age do not consider how their collective actions could affect their own medical expenditure in retirement, ending up increasing the overall insurance premium and tax burden in the long term. This paper also assess how much this cross generation externality could be resolved through taxation and subsidization.

A change in alcohol or cigarette excise tax is often followed by equity issues due

[3]It is ideal to regulate these with other tools than taxation, such as harsher punishment, because relative price change is a matter that affects a broad range of people including milder users of those goods.

[4]We abstract from these because the main purpose of this paper is to emphasize the significant welfare effects of sports goods subsidization rather than disregard the full effects of health excises taxes.

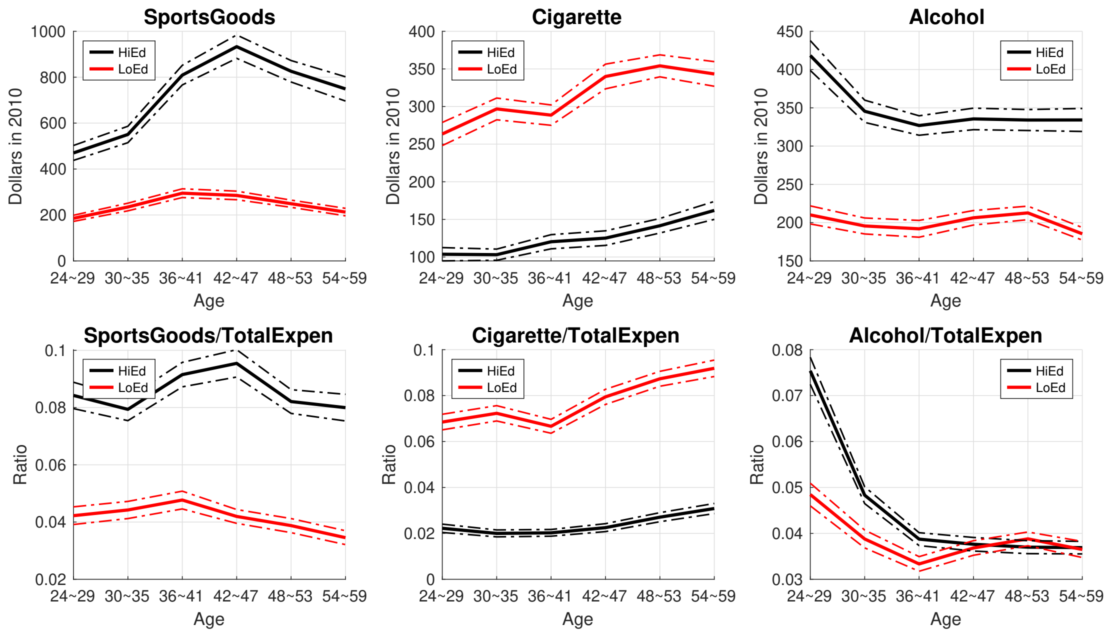
Figure 2: Medical Expenditure and Insurance Premium



to the stark difference in consumption patterns by socioeconomic status; sports goods subsidization, if implemented, cannot be exempt from the issue as well. For example, Figure 3 shows that, regardless of its income, the high education group consumes more sports goods and less cigarette than the low education group. This implies that taxation on cigarette and subsidization on sports goods, despite their positive effects on health, could have a negative distributive effect. Alcohol is relatively in the gray zone in the sense that the high education group absolutely consumes more of it, but it could be only due to high income for later in the life cycle. Nonetheless, the Figure shows that, if anything, taxation on alcohol is likely to act in favor of the low education group. This paper investigates these distributive effects of the optimal policies as well. We assess whether each policy is justifiable from the distributive point of view.

We build an overlapping generations model of working age that address the two forms of externality mentioned above. Towards this goal, we follow five important steps. (1) Our health status in the model should reflect the total medical expenditure as much as possible, so we define a new health measure as the fitted value of regressing medical expenditure on various health conditions. We use the Medical Expenditure Panel Survey (MEPS) to do this, since it is the only micro data set with a full medical expenditure variable. We directly use this measure as the incurred medical expenditure in the model. (2) To account for externality, we estimate the health production function that endogenously evolves depending on health behaviors (alcohol, cigarette, and exercise), using Panel Survey of Income Dynamics (PSID), which is the only long term panel

Figure 3: Sports Goods, Cigarette, Alcohol : High VS Low Education



data set that provides with health conditions and behaviors. Therefore, the chosen health conditions in the new health measure are all of those shared in both PSID and MEPS. (3) The health behavior variables in PSID are in count units, thus we rescale them into units of dollars and time by comparing with the Consumer Expenditure Survey (CEX) and American Time Use Survey (ATUS) data, so as to precisely reflect their opportunity costs and fit them into a single budget constraint. This is especially important in identifying the CES complementarity between sports goods and exercise with increase in wage along the life cycle, which is impossible through an exercise variable in units other than time. Also, tax distortions cannot be properly expressed unless control variables are fitted into a single budget constraint through dollar terms. (4) We estimate the out-of-pocket medical expenditure function, one of the main sources of externality. (5) We calibrate the model to match the literature demand elasticities to accurately reflect the relationship between tax/subsidy and health behaviors.

The main results are as follows. The welfare gain from optimal subsidization of sports goods ($146.08 per household every year) is about 16 times higher than that from optimal taxation on alcohol and cigarette ($8.85 per household every year). The former decreases the aggregate medical expenditure by 3.2%, while the latter only by 0.2%. While the low education group experiences welfare loss from optimal taxation on the unhealthy goods, the optimal subsidization of sports goods attains Pareto improvement, even though the health status of low education does not improve. The welfare gain from improving retirement health status is about 43% of the total gain.

Among various strands of related literature, this paper especially contributes to two strands of literature. The first is the literature with endogenous health capital models. Initially inspired by Grossman (1972), the recent health economics field has seen endogenous health production functions in papers such as Cole et al. (2019), Yogo (2016), Ozkan (2014), Fang and Gavazza (2011), Aizawa and Fang (2013) and Jung and Tran (2008). This paper is the first to incorporate an endogenous health production function with specific health behaviors (alcohol, cigarette, and exercise) in the health macroeconomic framework.

The second strand is the optimal taxation literature. Initially inspired by Ramsey (1927), this strand has seen various optimal taxation analyses on health goods in papers such as Grossman et al. (1993), Pogue and Sgontz (1989), Kenkel (1996), Gruber and Kőszegi (2004), O'Donoghue and Rabin (2006), Warner et al. (1995), DeCicca et al. (2013), and Warner et al. (1995). Our paper, as opposed to these which mostly focus on externality from micro economic environment, is the first optimal taxation paper that comprehensively accounts for medical expenditure related externality from equilibrium effects.

The structure of this paper is as follows. We describe the model in Section 2, the theory behind the two important channels of externality in Section 3, the data-work and calibration in Section 4, the quantitative results in 5, and the conclusion in 6.

2 Model

2.1 Environment

We construct a overlapping generations model in which a measure one continuum of households live for periods $t \in \{0, \cdots, \mathcal{T}\}$ [5]. Each household is initially endowed with a health status represented by medical expenditure m_0. In each period, a household is endowed with 24 hours, which is allocated across leisure l, exercise e, and labor $24 - P_l l - P_e e$ that generates income with hourly wage W_t, where P_e and P_l are hourly unit adjustment variables for computational reason. It is also given a health status m, which is accompanied by an out-of-pocket medical expenditure cost,

$$oop(m, Z) = \overline{oop} * Z + \widehat{oop} * P_m m, \tag{2.1}$$

where P_m is its price, and Z is the scaling factor that clears the market. $\overline{oop} * Z$ affects the deductible, $P_m \widetilde{m} = \frac{\overline{oop}*Z}{1-\widehat{oop}}$. A household earns a fixed income A_t, but pays a health insurance premium cost $prem_t * Z$[6].

In each period, a household gains utility from consumption c, leisure l, alcohol a, cigarette s, sports goods g, and exercise e, in the form of the following separable period utility function,

$$U(c, l, a, s, g, e) = \alpha \frac{[\mu c^\rho + (1-\mu)\ell^\rho]^{\frac{\sigma}{\rho}}}{\sigma} + \delta \frac{a^\phi}{\phi} + \nu \frac{s^\psi}{\psi} + \xi \frac{[\chi g^\theta + (1-\chi) e^\theta]^{\frac{\eta}{\theta}}}{\eta}. \tag{2.2}$$

The utility is discounted at the rate β every period. In the terminal period $\mathcal{T}$, a household additively receives the following utility,

$$\beta V(h', \mathcal{T}+1) = \beta \omega \frac{(h')^\gamma}{\gamma}. \tag{2.3}$$

where $h = \bar{m} - m$ is the health capital, h' is the future health, and $\bar{m}$ is the worst medical expenditure possible.

A household could affect its future medical expenditure m' through the following

[5] Although all fundamentals are potentially different across households, we suppress the subscript i for simpler expressions in this subsection.

[6] By $prem_t$ having the same scaling factor Z as $\overline{oop}$, Z represents the increase in total medical expenditure, that is, if every m_{it} is multiplied by x, $Z = x$ in the equilibrium.

production function,

$$P_m m' = \mathcal{M}_t(e,a,s,m) \equiv \bar{\zeta}_t + \zeta_m P_m m + \zeta_a P_a a + \zeta_s P_s s + \zeta_e P_e e \tag{2.4}$$

$$+ (\zeta_{am} P_a a + \zeta_{sm} P_s s + \zeta_{em} P_e e) P_m m, \tag{2.5}$$

but faces the following constraint

$$m' \geq m, \tag{2.6}$$

which implies that the health cannot improve from the past. m is the only savings factor in this model.

Households purchase c, a, s, and g at their respective final prices $(1+\tau)P_c$, $(1+\tau+\tau_a)P_a$, $(1+\tau+\tau_s)P_s$, and $(1+\tau+\tau_g)P_g$, where τ is the sales tax rate, τ_x generically denotes an additional excise tax rate on good x, and P_x generically denotes the price of good x.

2.2 Market Clearing and Government Budget

In an overlapping generation environment, the total medical expenditure is covered by the government, the health insurance system, or out-of-pocket from households,

$$\int_i \sum_{t=0}^{\mathcal{T}} P_m m_{it} = M\left(\int_i \sum_{t=0}^{\mathcal{T}} P_m m_{it}\right) + \int_i \sum_{t=0}^{\mathcal{T}} \left\{ prem_{it} * Z + oop_i(m_{it}, Z) \right\}, \tag{2.7}$$

where $M(\cdot)$ is the government portion of the total medical expenditure covered.

The government budget constraint holds as well,

$$G + M\left(\int_i \sum_{t=0}^{\mathcal{T}} P_m m_{it}\right) = \int_i \sum_{t=0}^{\mathcal{T}} \left\{ \sum_{x\in\{c,a,s,g\}} \tau P_x x_{it} + \sum_{y\in\{a,s,g\}} \tau_y P_y y_{it} \right\}, \tag{2.8}$$

where G is the total government expenditure other than medical expenditure subsidy. We assume that there is no sales tax on medical expenditure[7]. Note that all forms of endogenous taxes (τ, τ_a, τ_s, τ_g) throughout the paper are distortionary. Though $G < 0$

[7] Many health care products and services are exempt from sales tax due to its different nature from other consumption goods. For example, medical services and devices are exempt in California.

indicates medical expenditure could be supported by other sources as well (possibly income tax).

2.3 Household Optimization

The household problem could be expressed in a recursive form

$$\begin{aligned}
V(h,t) = & \max_{c,l,a,s,g,e,h'} \{U(c,l,a,s,g,e) + \beta V(h',t+1)\} \\
s.t. \quad & (1+\tau)P_c c + (1+\tau+\tau_a)P_a a + (1+\tau+\tau_s)P_s s \\
& \quad + (1+\tau+\tau_g)P_g g + prem_t * Z + oop(\bar{m}-h, Z) \\
& \quad = W_t * (24 - P_e e - P_l l) + A_t, \\
& \text{eq. (2.4)}, \\
& \text{eq. (2.6)}.
\end{aligned} \tag{2.9}$$

2.4 Equilibrium

We define the sets of fixed parameters,

$$\Theta_i \equiv \{\beta_i, \alpha_i, \mu_i, \rho_i, \sigma_i, \delta_i, \phi_i, \nu_i, \psi_i, \xi_i, \chi_i, \theta_i, \eta_i, \omega_i, \gamma_i\}$$

$$\Omega_i \equiv \left\{oop_i, \{A_{it}, prem_{it}, W_{it}\}_{0\le t\le \mathcal{T}}\right\}$$

$$\mathcal{H}_i \equiv \left\{m_{i0}, \bar{m}_i, \zeta_{m,i}, \zeta_{e,i}, \zeta_{a,i}, \zeta_{s,i}, \zeta_{em,i}, \zeta_{am,i}, \zeta_{sm,i}, \left\{\bar{\zeta}_{it}\right\}_{0\le t\le \mathcal{T}}\right\}$$

$$\mathcal{G} \equiv \{P_c, P_a, P_s, P_g, P_m, P_l, P_e, G, M\}$$

$$\Psi = \{\tau_a, \tau_s, \tau_g\},$$

and control variables,

$$\mathcal{X}_{it} \equiv \{c_{it}, l_{it}, a_{it}, s_{it}, g_{it}, e_{it}, h_{i,t+1}\}.$$

Given $\{\Theta_i, \Omega_i, \mathcal{H}_i\}_{i\in[0,1]}$, $\mathcal{G}$, and Ψ, we define the equilibrium to be a set of household decisions $\left\{\{\mathcal{X}_{it}\}_{0\le t\le\mathcal{T}}\right\}_{i\in[0,1]}$, the health insurance scale Z, and the sales tax τ that satisfies the following conditions :

1. Given Z and τ, each household i decides $\left\{\{\mathcal{X}_{it}\}_{0\le t\le\mathcal{T}}\right\}_{i\in[0,1]}$ that solves (2.9).

2. Z clears the health care market as in (2.7).

3. τ clears the government budget constraint as in (2.8).

2.5 Ramsey Problem

The main interest of this paper is to find the equilibrium that maximizes the following social welfare function,

$$\mathcal{W} = \int_i \pi_i \left\{ \sum_{t=0}^{\mathcal{T}} \beta_i^t U(c_{it}, l_{it}, a_{it}, s_{it}, g_{it}, e_{it}) + \beta_i^{\mathcal{T}+1} V_i(h_{\mathcal{T}+1}, \mathcal{T}+1) \right\}, \tag{2.10}$$

with respect to Ψ, given $\{\Theta_i, \Omega_i, \mathcal{H}_i\}_{i\in[0,1]}$, and $\mathcal{G}$, where π_i is the distribution of the pareto weights. Note that the social planner cannot directly monitor individual decisions $\mathcal{X}_{it}$, so is bound by the first order conditions from (2.9). We illustrate the full set of equilibrium conditions in the Appendix.

2.6 Retirement

Retirement is, if tax rates and initial health given, exogenously incorporated to consider the possibility that it could largely affect the medical expenditure related externalities, since medical expenditure grows with age in the data.[8] We define the quadratic health transition function

$$m_{i,t+1} = R_0(i,t) + R_1(i,t)\kappa_{it} m_{it} + R_2(i,t)(\kappa_{it} m_{it})^2 \tag{2.11}$$

and quadratic exit probability function

$$\log \frac{q_{i,t+1}}{1 - q_{i,t+1}} = Q_0(i,t) + Q_1(i,t) m_{it} + Q_2(i,t) m_{it}^2 \tag{2.12}$$

of retirement to derive the tax revenue, the medical revenue, and total medical expenditure. We assume $q_{i,\mathcal{T}+1} = 0$ and add exogenous κ_{it} to consider that health transition could only be estimated for population alive.

At each period $t \in \{\mathcal{T}+1, \cdots, \mathcal{K}\}$, the retired household i solves the following

[8] We abstract from endogenous health in retirement.

static problem given m_{it}, τ, Ψ, and Z,

$$\max_{c_{it},a_{it},s_{it},g_{it}} \sum_{x\in\{c,a,s,g\}} \mathcal{A}_{x,it} \log x_{it}$$

$$s.t.$$

$$\sum_{x\in\{c,a,s,g\}} (1+\tau+\tau_x) P_x x_{it} = A_{it} - prem_{it} * Z - oop_i^{ret}(m_{it}, Z),$$

where $\mathcal{A}_{x,it}$ is the weight on the separable utility of a generic good x, oop_i^{ret} is out-of-pocket medical expenditure function in retirement, and $\tau_c = 0$. Note that the resulting value functions are not related to the terminal utility of working age, but instead we assume that the entire health-related utility of retirement is summarized in the terminal utility.[9] We define this problem only to apply economic rules to the retirement tax revenue. In particular, this prevents the tax sources from being infinite by fixing the expenditure rates of each good to the data levels. Then we define the tax revenue as

$$RT_i = \sum_{t=\mathcal{T}+1}^{\mathcal{K}} \left[\prod_{v=\mathcal{T}+1}^{t} (1-q_{iv}) \right] \times \left[\sum_{x\in\{c,a,s,g\}} \tau P_x x_{it} + \sum_{y\in\{a,s,g\}} \tau_y P_y y_{it} \right],$$

the total medical expenditure as,

$$RM_i = \sum_{t=\mathcal{T}+1}^{\mathcal{K}} \left[\prod_{v=\mathcal{T}+1}^{t} (1-q_{iv}) \right] \times P_m m_{it}$$

and the health care revenue (out-of-pocket payment and health insurance premium) as,

$$RI_i = \sum_{t=\mathcal{T}+1}^{\mathcal{K}} \left[\prod_{v=\mathcal{T}+1}^{t} (1-q_{iv}) \right] \times \left[prem_{it} * Z + oop_i(m_{it}, Z) \right].$$

Note that $RT_i(\tau, \Psi)$, $RM_i(m_{i,\mathcal{T}+1})$, and $RI_i(m_{i,\mathcal{T}+1}, Z)$ are fixed once $m_{i,\mathcal{T}+1}$, Z, and the tax rates (τ, Ψ) are decided. We use these to extend the definition of the market

[9] By separating this retirement utility from the terminal utility, it is easier to decompose the effects of taxation between within-working-age and retirement-to-working externalities. In particular, we do not fix the health in the terminal utility but fix the medical expenditure.

clearing condition and the government budget constraint,

$$\int_i TM_i = M\left(\int_i TM_i\right) + \int_i TI_i, \tag{2.13}$$

$$G + M\left(\int_i TM_i\right) = \int_i TT_i, \tag{2.14}$$

where

$$TT_i = \sum_{t=0}^{\mathcal{T}} \left\{ \sum_{x\in\{c,a,s,g\}} \tau P_x x_{it} + \sum_{y\in\{a,s,g\}} \tau_y P_y y_{it} \right\} + RT_i,$$

$$TM_i = \sum_{t=0}^{\mathcal{T}} P_m m_{it} + RM_i,$$

$$TI_i = \sum_{t=0}^{\mathcal{T}} \{prem_{it} * Z + oop_i(m_{it}, Z)\} + RI_i.$$

Starting the retirement with better health could decrease the severity of medical expenditure and prolong the life to add tax and medical revenue, while resulting in longer periods of medical expenditure occurrence. The trade-off is incorporated in our retirement functions.

3 Theoretical Analysis

Why could it be optimal to improve the households' health beyond the market levels? The negative effects of medical expenditure on health insurance costs and tax burden are not internalized in individuals' problems. These forms of externality make households under-produce health in the market.

To illustrate the externality involved, we refer to the following static social planner's problem of a representative agent whose control variables are monitored and Z is still given.

$$\max_{c,l,a,s,g,e,m',\tau,\Psi} \{U(c,l,a,s,g,e) + \beta V(\bar{m} - m')\}$$
$$\begin{aligned} s.t. \quad & (1+\tau)P_c c + (1+\tau+\tau_a)P_a a + (1+\tau+\tau_s)P_s s \\ & + (1+\tau+\tau_g)P_g g + prem * Z + \overline{oop} * Z + \widehat{oop} * P_m m' \\ & = W * (24 - P_e e - P_l l) + A, \end{aligned} \tag{3.1}$$

$$P_m m' = \mathcal{M}(e,a,s,m)$$

$$prem * Z + \overline{oop} * Z + \widehat{oop} * P_m m' = P_m m' - M(P_m m')$$

$$G + M(P_m m') = \sum_{x \in \{c,a,s,g\}} \tau P_x x + \sum_{y \in \{a,s,g\}} \tau_y P_y y$$

Without loss of generality, we take s as an example of an unhealthy good, that is, $\zeta_s + \zeta_{sm} m > 0$. A simplified version of the first order condition with respect to s is

$$\delta s^{\phi-1} + P_s(\zeta_s + \zeta_{sm} m)\left[-\beta V'(h')/P_m - \lambda \widehat{oop} + \Phi\right] = \lambda P_s, \tag{3.2}$$

where λ is the budget constraint multiplier,[10] and

$$\Phi \equiv \varphi * \{\widehat{oop} - [1 - M'(P_m m')]\} + \vartheta * [-M'(P_m m')], \tag{3.3}$$

where $\varphi \geq 0$ and $\vartheta \geq 0$ are multipliers for the health care market clearing condition and the government budget constraint, respectively. Compare with the respective individual first order condition of the Ramsey environment,

$$\delta s^{\phi-1} + P_s(\zeta_s + \zeta_{sm} m)\left[-\beta V'(h')/P_m - \lambda \widehat{oop}\right] = \lambda P_s(1 + \tau + \tau_s). \tag{3.4}$$

If we assume $\tau + \tau_s = 0$, Φ is the only difference between the two equations. The first and the second term on the right hand side of (3.4) reflect that depreciation in health capital accompanies rise in the household's sponsorship (premium and out-of-pocket expenditure) of health spending and the distortionary tax burden, respectively. Basically, the gap between the two equations arise because (1) the households' direct payments of medical expenditure is not covering the full medical expenditure generated and (2) the government's medical expenditure burden is proportional to the total

[10] $\tau + \tau_s$ terms are cancelled out as the first order condition with respect to τ_s implies $\lambda = \vartheta$

medical expenditure incurred. Combining a reasonable assumption $M'(x) = r > 0$ with

$$\widehat{oop} < 1 - M'(P_m m'), \tag{3.5}$$

which is empirically true in our data, Φ takes the same sign as $-\beta V'(h')/P_m < 0$ which reflects how much future health is cared about. Thus, the social planner cares about health more than individuals do, so the optimal cigarette is lower than the market level.

These gaps become the indirect sources of externality in which a non-internalized part of a household's decision affect the welfare of another. For example a decrease in expenditure of s by an atom of households could enhance their health and decrease medical expenditure, thereby decreasing the Z and tax burden of all households. The social planner considers such cross effects of health, whereas the individuals do not internalize them in their problems. Although our 2 period model example is limited to within age externality, the full dynamic model used in our quantitative analysis generates externality across age groups as well.

The key idea of this paper is to, although not perfectly, partially compensate this gap with higher $\tau + \tau_s$ when individual control variables are unobservable by the social planner. If $\tau + \tau_s$ rises, individuals would purchase less s simply because it is cheaper, but the consequence could be welfare improving. Decreasing tax of healthy goods (or subsidizing it) has analogous effects : health improves to indirectly drop the tax burden and health insurance costs.

Of course, direct health improvement and resolution externality are not the only effects involved in these taxation and subsidization policies. We also take into account how taxation of unhealthy goods and subsidization of healthy goods directly affect the tax burden. Taxation alleviates the tax burden and decreases ϑ, while subsidization acts in the opposite way. Furthermore, the Ramsey principle states that goods with higher demand elasticities tend to be charged lower tax in the optimum. This paper analyzes the optimal Ramsey policies under these trade-offs.

4 Data

We use CEX (Consumer Expenditure Survey) of 2005 ~ 2017 to obtain moments of c, a, s, g[11], and $prem$; PSID (The Panel Study of Income Dynamics) of 2005 ~ 2017 to obtain parameters of W and $\mathcal{M}$; MEPS (Medical Expenditure Panel Survey) of 2008 ~ 2016 reformulated into CPS defined family scale to obtain moments of m, $\bar{m}$, and education ratios edu_j ($j \in \{H, L\}$) and estimations of oop; ATUS (American Time Use Survey) of 2005 ~ 2017 to obtain moments of e and l; and HRS (Health and Retirement Study) of 2004 ~ 2016 to obtain health transitions and exit probabilities of retirement. We use CPI to have 2010 as the dollar base year.

We define that the working age is 24 ~ 59 and the retirement age is 60 ~ 95. A period in the model is 6 years, thus $\mathcal{T} = 5$ and $\mathcal{K} = 11$, and all flow values are annual. We are especially interested in heterogeneity across education groups, where the high education group is defined to be families of a head with at least associate college degree, and low education group is the rest. We decide that a single household in the model to be a family in the data, since the sample units of PSID and CEX are of family scale and MEPS could also be reformulated into family data. Thus c, a, s, g, and m of a household are those of a family. On the other hand, we assume that the time variables e and l belong to the head data, since the sample unit of ATUS data is an individual.

4.1 Current Tax Rates

Out of the total federal excise tax revenue in 2019, alcohol accounts for 12.5% and cigarette accounts for 10%[12], and federal and state excise tax on tobacco account for about $\tau_s = 0.44$ of the retail price[13]. We combine these facts with the CEX alcohol and cigarette consumption data and the national average sales tax rate $\tau = 0.08$ to get an estimation of τ_a through,

$$\frac{\tau_s \Sigma_t P_s s_t}{\tau_a \Sigma_t P_a a_t} = \frac{10}{12.5},$$

and we get $\tau_a = 0.19$[14].

[11] g includes sportswear; sports equipments except for hungting and fishing; social, recreation, health club membership; fees for participant sports; and participant sports, out-of-town trips

[12] TPC (2020)

[13] Orzechowski and Walker (2017)

[14] CEX only provides consumption data with taxes.

4.2 Health Measure

Table 2: Health Measure

	Dependent variable:	
	Medical Expenditure	
	Working Age	Retirement
	(1)	(2)
Health Very Good	380.878* (194.615)	−273.409 (374.285)
Health Good	720.355*** (204.132)	1,332.875*** (375.647)
Health Fair	1,238.776*** (284.460)	3,992.979*** (435.102)
Health Poor	5,122.737*** (490.486)	10,486.960*** (594.366)
High Blood Pressure	504.949*** (179.994)	598.784** (265.171)
Heart Disease	2,480.572*** (270.117)	4,525.044*** (265.654)
Lung Disease	1,408.100*** (466.513)	2,150.475*** (332.510)
Stroke	1,617.078*** (502.247)	3,689.255*** (389.014)
Cancer	4,861.035*** (326.265)	4,243.364*** (274.102)
Diabetes	2,998.888*** (287.448)	2,577.419*** (286.440)
Arthritis	1,641.234*** (200.256)	1,436.453*** (247.463)
Heart Attack	863.757 (559.072)	
High Cholesterol	1,294.319*** (180.556)	
Asthma	1,055.479*** (243.167)	
IADL Help	4,968.398*** (602.764)	
ADL Help	11,501.780*** (794.605)	
Work Limitation	3,798.352*** (399.335)	
Housework Limitation	821.990 (504.277)	
K6	31.809* (17.572)	
Obese Class 2	316.553 (249.430)	
Obese Class 3	637.332** (296.379)	
Constant	3,975.296*** (154.887)	5,957.393*** (338.399)
Observations	68,574	28,872
R^2	0.058	0.071
Adjusted R^2	0.058	0.071
Residual Std. Error	18,492.690 (df = 68552)	19,841.480 (df = 28860)
F Statistic	200.586*** (df = 21; 68552)	200.815*** (df = 11; 28860)
Note:		*p<0.1; **p<0.05; ***p<0.01

We define the health measure m as the fitted values of regressing the medical expenditure of a family on various health conditions of the head[15]. The first column of

[15] Not considering the endogeneity, if anything, underestimates the coefficients.

Table 2 is the OLS result of working age population, and the second column is that of retirement. The chosen health conditions are those shared in both MEPS and PSID (HRS for retirement), so we can apply the health measure derived from MEPS data to PSID/HRS to obtain the health production function and transitions[16]. It was necessary to connect the different data sets because MEPS is the only data set that provides with full medical expenditure data not limited to out-of-pocket and PSID (HRS for retirement) is one of the best panel data set that provides long term health conditions and behaviors for each sample. We set $P_m\bar{m} = \$46587.7$ to be the health measure when all health conditions are at worst possible status[17].

Figure 4: Health Measure and Medical Expenditure

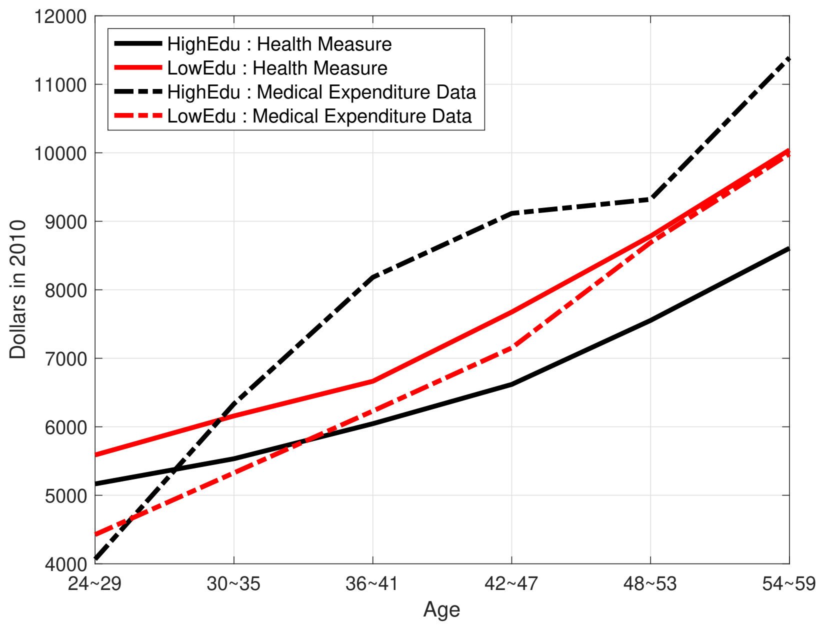


Figure 4 shows that health measure does not explain the raw medical expenditure gap across education groups, but it is consistent with Ozkan (2014) [18]. Also it explains well the rising medical expenditure along the life cycle.

[16]In PSID, a sample falls into ADL (Activities of Daily Living) Help if one is getting helped with bathing, dressing, eating, going to bed or chair, walking, going out, or toileting; IADL (Instrumental Activities of Daily Living) Help if one is getting helped with meal preparation, shopping, money managing, or phone calls; Housework Limitation if one is having heavy or light housework difficulty; High Cholesterol if one has every had other chronic disease. K6 is mental health assessment ranging 0(best)-24(worst).

[17]We apply this even if the coefficient of a health condition is negative.

[18]In the working age, the health care gap is explained by the gap in preventive care, while this paper is mainly interested in curative care.

4.3 Health Production

We use the coefficients of regressing health measure of 6 years future m' on present health, alcohol, cigarette, exercise, and interaction terms with present health, while controlling for the variables that could possibly affect the future health. The result is in Table 3. Note that time use variables are in hourly unit. Counts of light physical activities, heavy physical activities, and strengthening activities from PSID are rescaled to match the correspondent variables of ATUS data and added up to form a single exercise variable[19]. Counts of consuming alcohol[20] and cigarette are rescaled to match the correspondent variables from CEX data[21]. We use the relevant coefficients of the first column in Table 3 directly as those of $\mathcal{M}$. The large interaction term between exercise and present health of high education in the second column makes it hard to solve the model, so I suppress the education dummy variable for this interaction term and instead use a common interaction term across education groups, as in the first column of Table 3.

Both columns show that 81.7% of current health is reflected on the future health. This implies that the cumulative effect of health production is high, and improvement of health in earlier age could result in big health difference in the end of life cycle. The marginal product of m at each education group's respective mean health status is shown in Table 4. A dollar spent on cigarette could be 17 to 121 times harmful than a dollar spent on alcohol, but both increase the medical expenditure by less than a dollar. On the other hand, an hour exercise everyday could save up to \$11,333.25 (\$188.89 per minute) every year for high education population. This amount to hourly saving of \$31.05.

[19]Among ATUS variables, we define "light" as baseball, billiards, boating, bowling, golfing, hiking, softball, vehicle touring/racing, walking yoga, and playing sports n.e.c.* (exclude fishing and hunting in accordance to the CEX sports goods definition); "heavy" as aerobics, basketball, biking, climbing, spelunking, caving, dancing, equestrian sports, fencing, football, gymnastics, hockey, martial arts, racquet sports, rodeo competitions, rollerblading, rugby, running, skiing, ice skating, snowboarding, soccer, cardio equipments, volley, water sports; "strenthening" as weightlifting/strength training, unspecified working out.

[20]The total drink frequency is derived by multiplying the answers for "on the days you drank, about how many drinks did you have?" to those for "on how many days have you had (if male head then 'five'/ if female head then 'four') or more drinks on one occasion?".

[21]Since a sample of the CEX data is family, we combine the frequencies of head and spouse in PSID for alcohol and cigarette.

Table 3: Working Age Health Production

	Dependent variable:	
	Future Health Status	
	(1)	(2)
Constant	2,620.883*** (179.429)	2,612.059*** (179.373)
HighEdu	−4.215 (154.539)	220.784 (168.907)
Health	0.817*** (0.013)	0.817*** (0.013)
Health*HighEdu	0.010 (0.018)	−0.018 (0.020)
Alcohol	0.379*** (0.110)	0.379*** (0.110)
Alcohol*HighEdu	−0.410*** (0.126)	−0.404*** (0.126)
Alcohol*Health	−0.00005*** (0.00001)	−0.00005*** (0.00001)
Alcohol*Health*HighEdu	0.0001*** (0.00001)	0.0001*** (0.00001)
Cigarette	0.273** (0.120)	0.273** (0.120)
Cigarette*HighEdu	0.347** (0.176)	0.318* (0.177)
Cigarette*Health	0.00000 (0.00001)	0.00000 (0.00001)
Cigarette*Health*HighEdu	−0.00004** (0.00002)	−0.00003* (0.00002)
Exercise	−140.613 (205.922)	−133.888 (205.844)
Exercise*HighEdu	−10,860.780* (6,259.779)	−55,647.300*** (14,969.650)
Exercise*Health	0.055*** (0.020)	0.055*** (0.020)
Exercise*Health*HighEdu		5.801*** (1.761)
Family Income	−0.0004 (0.0003)	−0.0004 (0.0003)
Family Wealth	0.0001** (0.00002)	0.0001*** (0.00002)
Housework Hours	6.290* (3.550)	6.317* (3.548)
Work Hours	−0.314*** (0.034)	−0.313*** (0.034)
Sex : Male	−112.715 (95.624)	−108.355 (95.593)
Race : Black	−15.907 (71.651)	−13.892 (71.623)
Race : Indian/Alaskan	26.194 (363.803)	30.978 (363.651)
Race : Asian	34.532 (249.396)	31.884 (249.292)
Race : Hawaiian/Islander	390.808 (852.460)	386.189 (852.099)
Race : Other	−38.217 (219.842)	−35.586 (219.750)
Marry : Single	−367.173*** (91.661)	−366.439*** (91.622)
Marry : Widowed	1,064.723*** (194.942)	1,074.482*** (194.882)
Marry : Divorced	553.198*** (110.361)	560.133*** (110.334)
Marry : Separated	166.834 (175.392)	156.719 (175.345)
Observations	11,619	11,619
R^2	0.513	0.514
Adjusted R^2	0.512	0.513
Residual Std. Error	3,068.253 (df = 11590)	3,066.951 (df = 11589)
F Statistic	436.755*** (df = 28; 11590)	422.427*** (df = 29; 11589)
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 4: Marginal Health Products at Mean Health

	E (per hr)	A (per \$)	S (per \$)
HiEd	$-11,333.250$	0.003	0.363
LoEd	347.857	0.016	0.275

4.4 Out-of-pocket Expenditure Function

Table 5 is the result of regressing out-of-pocket medical expenditure on our health measure instead of the actual total medical expenditure. It shows that households, whether high or low education, pay less than 10 cents for each dollar of medical expenditure incurred, implying that it could be an important source of externality. We use these coefficients as $\overline{oop}_i$ and $\widehat{oop}_i$. The following insurance thresholds are $P_m\tilde{m}_H = \$824.77$ and $P_m\tilde{m}_L = \$437.91$ in the working age.

Table 5: Out-of-pocket Medical Expenditure Function

	Dependent variable:			
	Working Age		Retirement	
	HighEdu	LowEdu	HighEdu	LowEdu
	(1)	(2)	(3)	(4)
Health Measure	0.051***	0.043***	0.055***	0.033***
	(0.003)	(0.002)	(0.006)	(0.003)
Constant	782.706***	419.080***	1,144.559***	814.063***
	(23.295)	(18.573)	(72.941)	(46.469)
Observations	32,897	35,677	12,372	16,500
R^2	0.009	0.012	0.008	0.006
Adjusted R^2	0.009	0.012	0.008	0.006
Note:				*p<0.1; **p<0.05; ***p<0.01

4.5 Elasticities

As our result depends largely on consumption change induced by taxation or subsidization, it is critical to match the relevant demand elasticities. We derive the following elasticities when the budget constraint shadow price λ is held constant,

$$\begin{aligned}
\varepsilon_a^{-1} &\equiv \left[\frac{da/a}{dP_a/P_a}\right]^{-1} = \delta(1-\phi)a^{\phi-1}/(\lambda P_a) - a\zeta_a^2\beta V''(h')/(\lambda P_a), &(4.1)\\
\varepsilon_s^{-1} &\equiv \left[\frac{ds/s}{dP_s/P_s}\right]^{-1} = \nu(1-\psi)s^{\psi-1}/(\lambda P_s) - s\zeta_s^2, &(4.2)\\
\varepsilon_e^{-1} &\equiv \left[\frac{de/e}{dP_g/P_g}\right]^{-1} = \frac{(1-\theta)}{\eta\pi-\theta}\left[\chi\left(\frac{g}{e}\right)^{\theta}\right]^{-1}\left[(1-\eta\pi) - e\frac{\zeta_e^2\beta V''(h')}{\lambda w - \zeta_e\beta V'(h')}\right]\\
&\times\left[(1-\chi)+\chi\left(\frac{g}{e}\right)^{\theta}\right] + e\frac{\zeta_e^2\beta V''(h')}{\lambda w - \zeta_e\beta V'(h')}. &(4.3)
\end{aligned}$$

We match the model average to the literature levels $\epsilon_a \in [0.49, 1.09]$, $\epsilon_s \in [0.3, 0.56]$, and $\epsilon_e \in [0.15, 0.35]$[22].

4.6 Calibration

The discount factors are brought from the annual literature levels $\beta_H = 0.99$ and $\beta_L = 0.94$[23], and $\sigma = -1$ is chosen from the macro literature[24]. We fix $\xi = 1$ for normalization of preference parameters. The after tax wage W_{it} is derived from PSID combined with the income tax rate of CEX for each education group, and A_{it} is calculated as the labor income $W_{it}(24 - P_e e_{it} - P_l l_{it})$ from PSID and ATUS minus the total expenditure in CEX. The price vectors are adjusted so as to normalize the mean of control variables (c, l, a, s, g, e, h) to one, that is, a price is the mean value of the respective good. This is to isolate the elasticity coefficients from the mean effect in the process of calibration as much as possible. We set $Z = 1$ in our calibration.

The first parts of Table 6 and Table 7 show the results of calibration through solving the model. α, μ, δ, ν, and χ are identified by the mean levels of l, a, s, g, and e. ρ and θ are identified by the rising l and g with respect to changes in W across life cycle, respectively. ϕ, ψ, and η are identified by demand elasticities of a, s, and e(with respect to P_g), respectively[25]. ω is identified by the change in health control

[22]For ε_e, Løyland and Ringstad (2009) gives an individual estimate 0.15 and an aggregate estimate 0.35 for the all sports related time use. For ε_a, Gallet (2007) reports the median value 0.492 in the literature but reports its own meta-analysis estimate 1.09. For ε_s, Adhikari et al. (2012) states this literature range.

[23]Cagetti (2003)

[24]The relative risk aversion is 2.

[25]The estimated health production function makes the effects of a and s small and e big. To be conservative with the results, we choose the upper bound targets for the ε_a and ε_s, and the lower bound target for ε_e.

Table 6: Calibration : High Education

	Values	Target	Data Mom	Model Mom
Alpha	59.229	lMean/lRange	212.140	212.140
Mu	0.090	aMean/aRange	5.218	5.218
Delta	0.050	sMean/sRange	2.184	2.184
Nu	0.019	gMean/gRange	2.269	2.269
Chi	0.157	eMean/eRange	9.671	9.671
Rho	-0.748	l4/lRange	212.440	212.440
Theta	-0.295	g4/gRange	2.569	2.570
Phi	0.082	EpsilonA	1.090	1.090
Psi	-0.751	EpsilonS	0.560	0.560
Eta	0.420	EpsilonE	0.150	0.150
Omega	0.00000	e1 - e6	0.103	0.103
Gamma	0.750	Vpp4+Vpp6-2*Vpp5 (Model)	0	-0.001

	24-29	30-35	36-41	42-47	48-53	54-59
prem	631.790	738.550	845.320	952.080	1,058.800	1,165.600
A	$-26,236$	$-31,822$	$-37,372$	$-42,881$	$-48,339$	$-53,763$
W (hourly)	26.499	30.564	34.630	38.696	42.759	46.827
Zetabar	0.109	0.112	0.114	0.122	0.127	0.129

Pc	Pa	Ps	Pg	Pl	Pe	Pm
22,692	183.330	55.097	667.930	18.630	0.312	43,727

Table 7: Calibration : Low Education

	Values	Target	Data Mom	Model Mom
Alpha	85.758	lMean/lRange	54.201	54.201
Mu	0.088	aMean/aRange	16.952	16.952
Delta	0.065	sMean/sRange	3.767	3.769
Nu	0.103	gMean/gRange	7.879	7.879
Chi	0.120	eMean/eRange	3.446	3.446
Rho	−26.106	l4/lRange	54.501	54.501
Theta	−5.251	g4/gRange	8.179	8.179
Phi	0.084	EpsilonA	1.090	1.090
Psi	−0.787	EpsilonS	0.540	0.556
Eta	0.284	EpsilonE	0.150	0.150
Omega	0.0002	s1 - s6	−0.265	−0.227
Gamma	−17.653	Vpp4+Vpp6-2∗Vpp5 (Model)	0	−0.0001

	24-29	30-35	36-41	42-47	48-53	54-59
prem	383.340	461.050	538.750	616.460	694.170	771.870
A	−11, 789	−13, 786	−15, 711	−17, 540	−19, 288	−20, 953
W (hourly)	17.987	19.727	21.467	23.207	24.947	26.685
Zetabar	0.035	0.036	0.050	0.056	0.064	0.069

Pc	Pa	Ps	Pg	Pl	Pe	Pm
14, 811	104.990	137.230	226.710	19.545	0.220	42, 829

Table 8: Calibration : Representative Household

	Values	Target	Data Mom	Model Mom
Alpha	75.411	lMean/lRange	117.780	117.780
Mu	0.089	aMean/aRange	6.660	6.660
Delta	0.061	sMean/sRange	3.030	3.033
Nu	0.046	gMean/gRange	2.674	2.674
Chi	0.165	eMean/eRange	5.076	5.076
Rho	−1.450	l4/lRange	118.080	118.080
Theta	−0.517	g4/gRange	2.974	2.974
Phi	0.084	EpsilonA	1.090	1.090
Psi	−0.753	EpsilonS	0.550	0.563
Eta	0.361	EpsilonE	0.150	0.150
Omega	0.255	s1 - s6	−0.330	−0.305
Gamma	−9.861	Vpp4+Vpp6-2∗Vpp5 (Model)	0	−0.0001

	24-29	30-35	36-41	42-47	48-53	54-59
prem	521.760	615.660	709.560	803.450	897.350	991.240
A	−16,854	−20,416	−23,928	−27,373	−30,755	−34,081
W (hourly)	22.729	25.764	28.800	31.836	34.871	37.907
Zetabar	0.476	0.496	0.546	0.601	0.645	0.673

Pc	Pa	Ps	Pg	Pl	Pe	Pm
19,202	148.640	91.469	472.540	19.334	0.244	6,985

Figure 5: Data Match : High Education

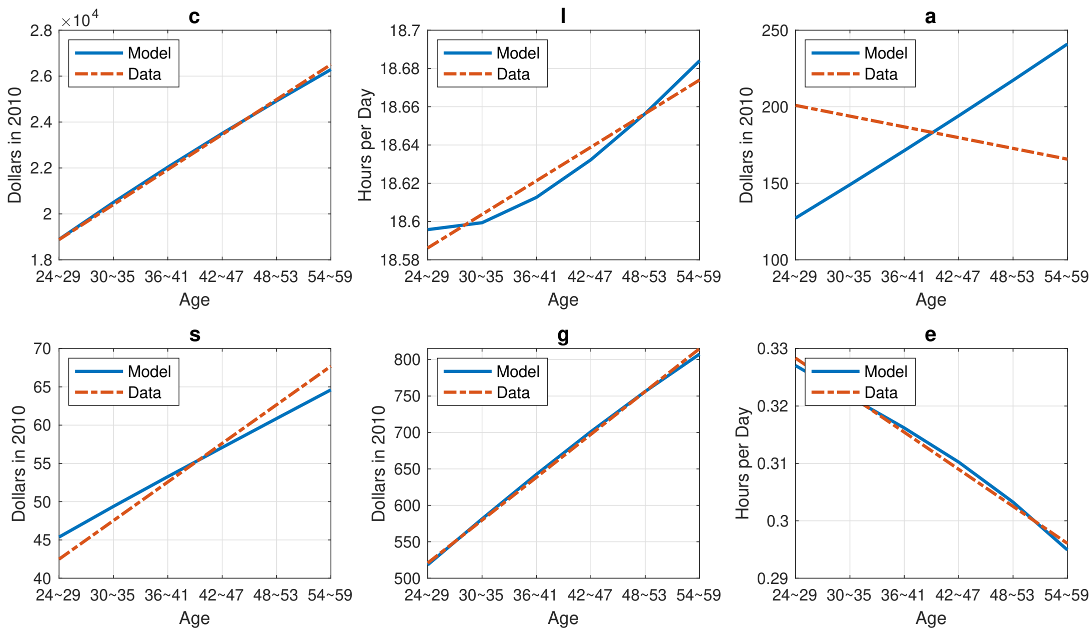


Figure 6: Data Match : Low Education

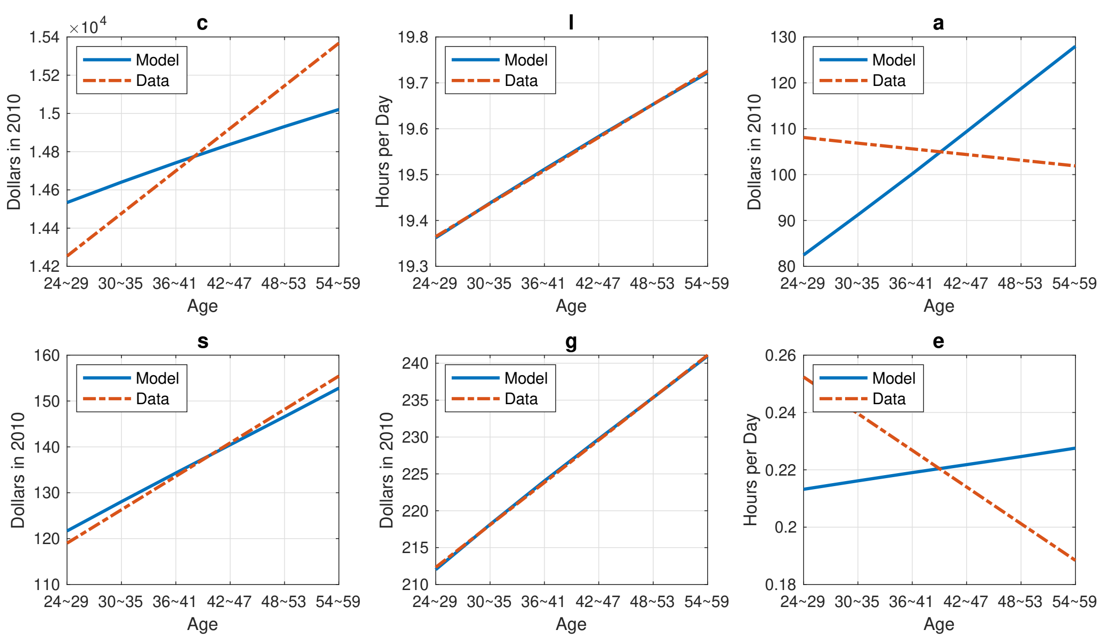
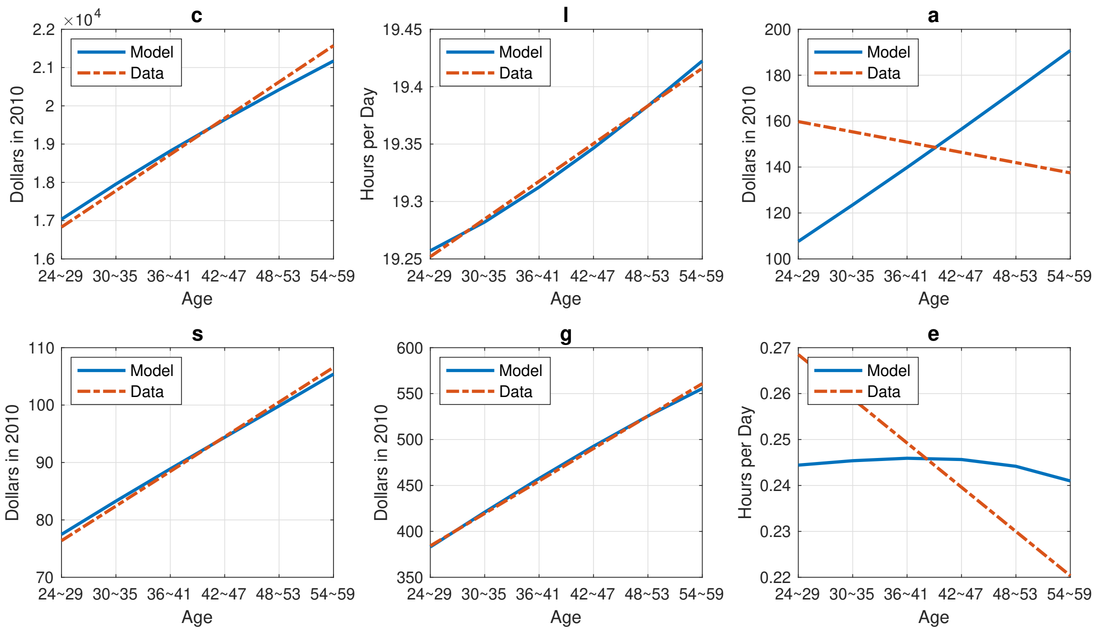


Figure 7: Data Match : Representative Household



variables across life cycle[26], and γ is chosen to avoid kink of $V''(h')$ in the final period. We linearly smooth the data moments of W, c, l, a, s, g, and e for faster calibration. We minimize the sum of squared deviations (some of them normalized by respective ranges as in Table 6 and Table 7) to calibrate these preference parameters. $\bar{\zeta}_{it}$ are flexibly chosen to exactly match the $P_m m$ data moments shown in Figure 4.

To calibrate the representative household model, we use the high education ratio $edu_H = 0.56$ from MEPS to linearly average out the target moments and health production, except for β which we geometrically average out[27]. The identification strategy is the same as above, and the results are in Table 8 and Figure 7.

4.7 Retirement Parameters

The retirement health discount factors κ_{it}, health transitions ($R_0(i,t)$, $R_1(i,t)$, $R_2(i,t)$), and exit probabilities ($Q_0(i,t)$, $Q_1(i,t)$, $Q_2(i,t)$) are reported in the Appendix A.1.

[26] We choose e for high education and s for low education because they turn out to be most influential in the respective health production functions.

[27] By doing so, multi year discount factor of the average is equal to the average of multi year discount factors.

4.8 Sponsorship Composition

The NHE reports that among the total health care cost, 28% is sponsored by the household, 20% by private businesses, 45% by governments, and 7% by other private sources (mostly philanthropy). We adjust the household premiums to incorporate the sponsor ratios of household, private businesses, and other private sources, and A_{it} are accordingly adjusted to match the total expenditures as well. In order to fill the household sponsor gap, we add to household premium, both working age and retirement, in proportion to the data premium. In order to incorporate the private business sponsor, we add to working age household premium in proportion to the data premium.[28] In order to incorporate other private sources, we add to household premium, both working age and retirement, in proportion to consumption in the data[29]. These additional components multiplied by scale factor Z are used to cover the market portion of total health care cost. $M'(\cdot) = r = 0.45$ naturally follows, with $M(\Sigma P_m m) = \$36{,}816$ (\$3,068 per household) and $G = \$22{,}648$ (\$1,888 per household).

5 Quantitative Analysis

5.1 Optimal Taxation : Representative Household

We define the welfare gain of taxation as the equivalent variation (EV) of lump-sum income transfer every year to the baseline specification, where the only existing tax is the sales tax τ. Table 9 shows some important results on the optimal taxation on unhealthy goods, alcohol and cigarette (Opt AS column).

1. The results of optimal taxes on alcohol and cigarette are not very different from the current tax system (Curr ASG column). The taxes are optimally $\tau_a = 0.12$ and $\tau_s = 0.53$ with the EV of \$8.85, and the current system $\tau_a = 0.19$ and $\tau_s = 0.44$ generates EV of \$8.43.

2. The high education group gains from optimal taxation on uhealthy goods with EV of \$3.75, whereas the low education makes loss with EV of -\$27.72. This

[28] We assume that the health cost covered by the employer is imposed on employee through lump-sum income contract.

[29] We assume that every household donates to general health care in proportion to the consumption level.

is because the gain for high education and loss for low education from optimal cigarette taxation (Opt S column) overrides the gain for low education and loss for high education from optimal alcohol taxation (Opt A column).

3. The aggregate medical expenditure represented by Z in the representative household specification decreases only by 0.2% (Z Rep and Z Base Rep rows).

4. τ in the representative household specification decreases by 0.4 percentage points (Tau Rep and Tau Base Rep rows), due to the direct tax collection of these policies.

It also shows some contrastive results for the optimal subsidization on sports goods per se (Opt G column).

1. The optimal subsidization is 54% above the new sales $\tau = 0.099$, which has increased by 1.5 percentage points due to the subsidization burden.

2. The EV is $146.1/8.8 = 16.6$ times larger than that of optimal taxes on uhealthy goods.

3. This policy attains Pareto improvement in the heterogenous specification. The high education group takes disproportionate gain with EV of $321.1 from this policy, and the low education sees positive gain as well, with EV of $37.3.

4. The medical expenditure burden represented by Z in the representative household specification decreases only by 3.2%.

We decompose the total effect of an optimal taxation into its insurance burden effect and tax burden effect by defining former to be the welfare gain from separately evaluating the optimal taxation in $r = 0$ specification[30]. We derive the results by comparing EV rows of Table 9 and Table 10. For example, $124.3 out of $146.1 (85%) of welfare gain from optimal subsidization of sports goods comes from resolving the insurance burden.

We also decompose the total effect of an optimal taxation into within-working-age effect and retirement effect by defining former to be the welfare gain from fixing the

[30]Another candidate is to plug in the optimal tax from $r > 0$ into $r = 0$ specification and evaluate the EV, but this could possibly result in negative health insurance effect even if it is potentially positive per se.

Table 9: Optimal Taxation Results : $r > 0$

	Curr ASG	Opt A	Opt S	Opt G	Opt AS	Opt ASG
TauA	0.189	0.120	0	0	0.123	0.111
TauS	0.443	0	0.523	0	0.525	0.497
TauG	0	0	0	−0.538	0	−0.534
Tau Rep	0.080	0.083	0.081	0.099	0.080	0.096
Tau Base Rep	0.084	0.084	0.084	0.084	0.084	0.084
Z Rep	1	1.002	1.000	0.970	1.000	0.968
Z Base Rep	1.002	1.002	1.002	1.002	1.002	1.002
Tau Het	0.080	0.083	0.081	0.098	0.080	0.094
Tau Base Het	0.084	0.084	0.084	0.084	0.084	0.084
Z Het	1.000	1.001	1.000	0.963	1.000	0.961
Z Base Het	1.002	1.002	1.002	1.002	1.002	1.002
EV	8.427	0.975	7.768	146.080	8.846	153.880
EV HiEd	28.535	−1.070	34.709	321.160	33.753	351.830
EV LoEd	−22.557	1.856	−29.498	37.309	−27.721	10.943

Table 10: Optimal Taxation Results : $r = 0$

	Curr ASG	Opt A	Opt S	Opt G	Opt AS	Opt ASG
TauA	0.189	0.108	0	0	0.112	0.099
TauS	0.443	0	0.476	0	0.478	0.458
TauG	0	0	0	−0.517	0	−0.514
Tau Rep	0.080	0.082	0.081	0.104	0.080	0.101
Tau Base Rep	0.083	0.083	0.083	0.083	0.083	0.083
Z Rep	1	1.003	1.000	0.950	1.000	0.947
Z Base Rep	1.003	1.003	1.003	1.003	1.003	1.003
Tau Het	0.080	0.082	0.081	0.104	0.080	0.101
Tau Base Het	0.083	0.083	0.083	0.083	0.083	0.083
Z Het	1.000	1.002	1.000	0.939	1.000	0.937
Z Base Het	1.003	1.003	1.003	1.003	1.003	1.003
EV	7.090	0.808	6.593	124.330	7.327	130.980
EV HiEd	27.507	−0.971	31.645	289.450	30.761	317.770
EV LoEd	−23.959	1.630	−27.884	13.789	−26.314	−11.401

medical expenditure of retirement. We derive the results by comparing EV rows of Table 9 and Table 11. Most importantly, only \$77.5 out of \$146.1 (53%) of welfare gain from optimal subsidization of sports goods comes from resolving the within-working-age externality. The rest (\$68.6, 47%) comes from improving the health condition of retirement.

Table 11: Optimal Taxation Results : Fixed Retirement Health

	Curr ASG	Opt A	Opt S	Opt G	Opt AS	Opt ASG
TauA	0.189	0.094	0	0	0.096	0.083
TauS	0.443	0	0.359	0	0.361	0.338
TauG	0	0	0	−0.439	0	−0.436
Tau Rep	0.080	0.083	0.082	0.096	0.081	0.093
Tau Base Rep	0.084	0.084	0.084	0.084	0.084	0.084
Z Rep	1	1.001	1.000	0.984	1.000	0.983
Z Base Rep	1.001	1.001	1.001	1.001	1.001	1.001
Tau Het	0.080	0.083	0.082	0.095	0.081	0.093
Tau Base Het	0.084	0.084	0.084	0.084	0.084	0.084
Z Het	1.000	1.001	1.000	0.983	1.000	0.982
Z Base Het	1.001	1.001	1.001	1.001	1.001	1.001
EV	3.990	0.609	3.971	77.463	4.587	81.434
EV HiEd	23.904	−0.968	23.138	169.540	22.240	189.790
EV LoEd	−25.704	1.407	−22.090	−17.496	−20.748	−36.891

Figure 8 shows the change in medical expenditure from optimal subsidization of sports goods per se. In the end of working age life cycle, the difference is about \$500 reduction every year. Figure 9 shows the change in control variables from optimal subsidization of sports goods per se. Due to the lower relative price of sports goods, the representative household spends about \$300 more about it every year, and physical activity as a complementary activity increases as well by about 1.5 minutes every day.

5.2 Optimal Sports Goods Subsidization

We focus more on optimal subsidization of sports goods as it is the most important tool in attaining Pareto improvement in our model, according to subsection 5.1. Table 12, Table 13, and Table 14 share the sames columns. Columns Rep_N are the results of maximizing the utility of representative household, those of LoEd_N are of low education group, and those of HiEd_N are of high education group. Columns Rep_1,

Figure 8: Health Cost after Opt G : Representative Household

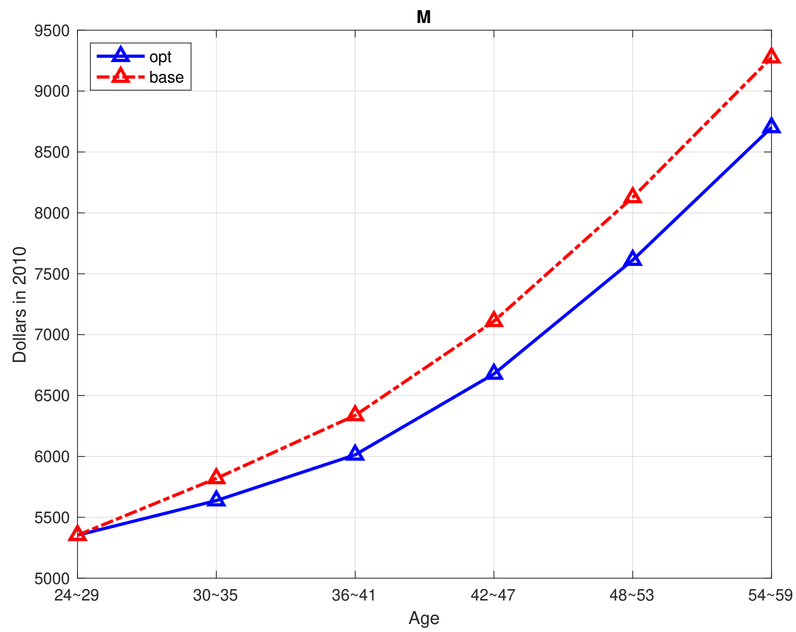
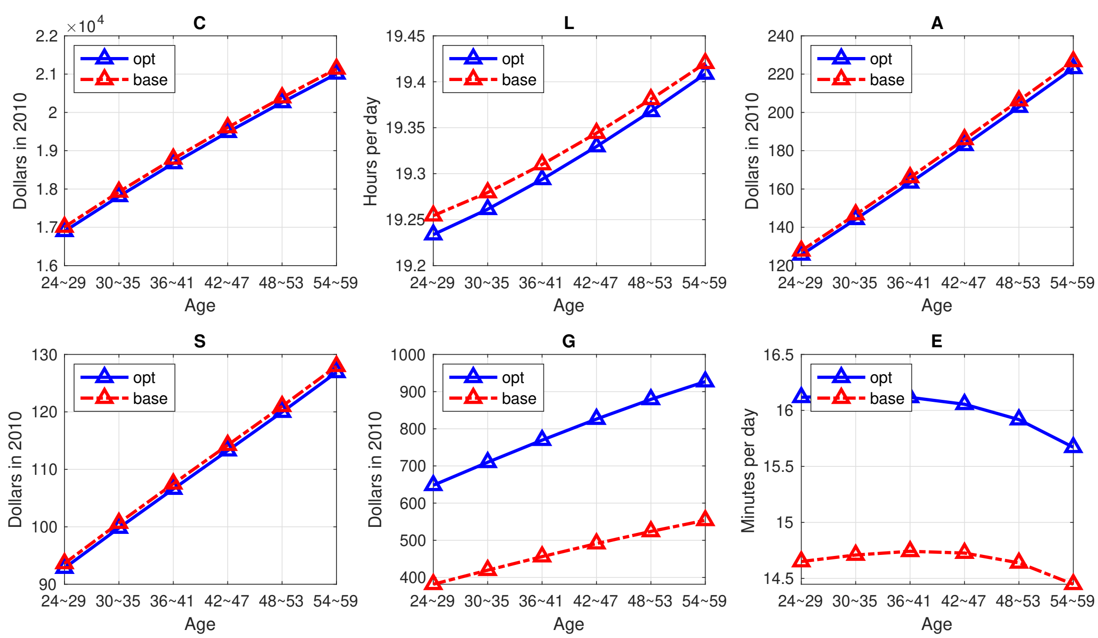


Figure 9: Health Cost after Opt G : Representative Household



LoEd_1, and HiEd_1 are fixing the taxes of alcohol and cigarette to the current system, and columns Rep_2, LoEd_2, and HiEd_2 are setting them to zeros.

Table 12 shows the firsthand results of optimal sports goods subsidization. LoEd_2 column shows that if $\tau_a = \tau_s = 0$ are fixed, the low education group can get maximum welfare gain of \$51.8, while the high education group enjoys welfare gain of \$244.9, through the optimal subsidy rate 39.4% above the new sales tax rate $\tau = 0.092$. The optimal subsidy rate could be a standard for lower bound of the optimal subsidy rate, assuming the economy is simply divided into high and low education. Similarly, the optimal subsidy rate 59.7% above the new sales tax rate $\tau = 0.10$ in column HiEd_2 could be a standard for upper bound of the policy.

Table 12: Optimal TauG Results : r>0

	CurrASG	Rep_1	LoEd_1	HiEd_1	Rep_2	LoEd_2	HiEd_2
TauA	0.189	0.189	0.189	0.189	0	0	0
TauS	0.443	0.443	0.443	0.443	0	0	0
TauG	0	−0.534	−0.392	−0.593	−0.538	−0.394	−0.597
Tau Rep	0.080	0.095	0.089	0.099	0.099	0.092	0.103
Tau Base Rep	0.084	0.084	0.084	0.084	0.084	0.084	0.084
Z Rep	1	0.968	0.978	0.963	0.970	0.980	0.965
Z Base Rep	1.002	1.002	1.002	1.002	1.002	1.002	1.002
Tau Het	0.080	0.094	0.088	0.098	0.098	0.092	0.102
Tau Base Het	0.084	0.084	0.084	0.084	0.084	0.084	0.084
Z Het	1.000	0.962	0.974	0.957	0.963	0.976	0.958
Z Base Het	1.002	1.002	1.002	1.002	1.002	1.002	1.002
EV	8.427	153.500	135.870	149.500	146.080	128.160	141.940
EV HiEd	28.535	347.460	272.300	357.050	321.160	244.910	332.690
EV LoEd	−22.557	14.512	28.888	−11.753	37.309	51.789	11.994

Figure 10 shows the following change in medical expenditure across group from executing LoEd_2 policy. It is noteworthy that due to the stark difference in marginal health product of exercise across education groups, only the high education group enjoys conspicuous reduction in medical expenditure. Nonetheless, the low education group gains from this policy, and this is mostly from resolving medical expenditure related externality. Figure 11 shows the change in medical expenditure is due to the high education group spending about \$400 more on sports goods every year and 1.5 minutes more on exercise every day.

The same analyses are presented for the specification in which τ_a and τ_s are fixed to the current levels, considering the possibility that the current unhealthy tax system

Table 13: Optimal TauG Results : r=0

	CurrASG	Rep_1	LoEd_1	HiEd_1	Rep_2	LoEd_2	HiEd_2
TauA	0.189	0.189	0.189	0.189	0	0	0
TauS	0.443	0.443	0.443	0.443	0	0	0
TauG	0	−0.514	−0.329	−0.587	−0.517	−0.330	−0.590
Tau Rep	0.080	0.101	0.091	0.106	0.104	0.094	0.109
Tau Base Rep	0.083	0.083	0.083	0.083	0.083	0.083	0.083
Z Rep	1	0.947	0.969	0.936	0.950	0.972	0.939
Z Base Rep	1.003	1.003	1.003	1.003	1.003	1.003	1.003
Tau Het	0.080	0.101	0.090	0.106	0.104	0.094	0.110
Tau Base Het	0.083	0.083	0.083	0.083	0.083	0.083	0.083
Z Het	1.000	0.937	0.964	0.925	0.939	0.967	0.928
Z Base Het	1.003	1.003	1.003	1.003	1.003	1.003	1.003
EV	7.090	130.610	106.110	124.950	124.330	99.513	118.560
EV HiEd	27.507	314.860	220.220	332.060	289.450	193.580	308.680
EV LoEd	−23.959	−10.077	9.185	−39.498	13.789	33.180	−14.984

Table 14: Optimal TauG Results : Fixed Retirement Health

	CurrASG	Rep_1	LoEd_1	HiEd_1	Rep_2	LoEd_2	HiEd_2
TauA	0.189	0.189	0.189	0.189	0	0	0
TauS	0.443	0.443	0.443	0.443	0	0	0
TauG	0	−0.435	−0.192	−0.558	−0.439	−0.195	−0.563
Tau Rep	0.080	0.092	0.084	0.099	0.096	0.087	0.102
Tau Base Rep	0.084	0.084	0.084	0.084	0.084	0.084	0.084
Z Rep	1	0.983	0.993	0.977	0.984	0.994	0.978
Z Base Rep	1.001	1.001	1.001	1.001	1.001	1.001	1.001
Tau Het	0.080	0.092	0.084	0.098	0.095	0.087	0.102
Tau Base Het	0.084	0.084	0.084	0.084	0.084	0.084	0.084
Z Het	1.000	0.982	0.993	0.975	0.983	0.994	0.976
Z Base Het	1.001	1.001	1.001	1.001	1.001	1.001	1.001
EV	3.990	80.710	50.451	66.960	77.463	47.184	63.498
EV HiEd	23.904	191.800	106.970	210.160	169.540	84.222	188.180
EV LoEd	−25.704	−43.214	−16.451	−89.619	−17.496	9.488	−64.798

Figure 10: Health Costs for for LoEd_2

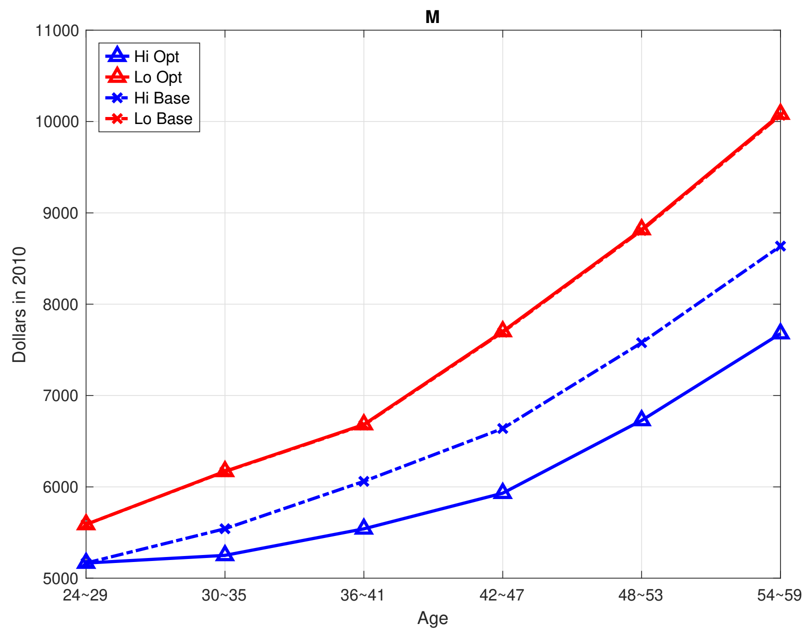
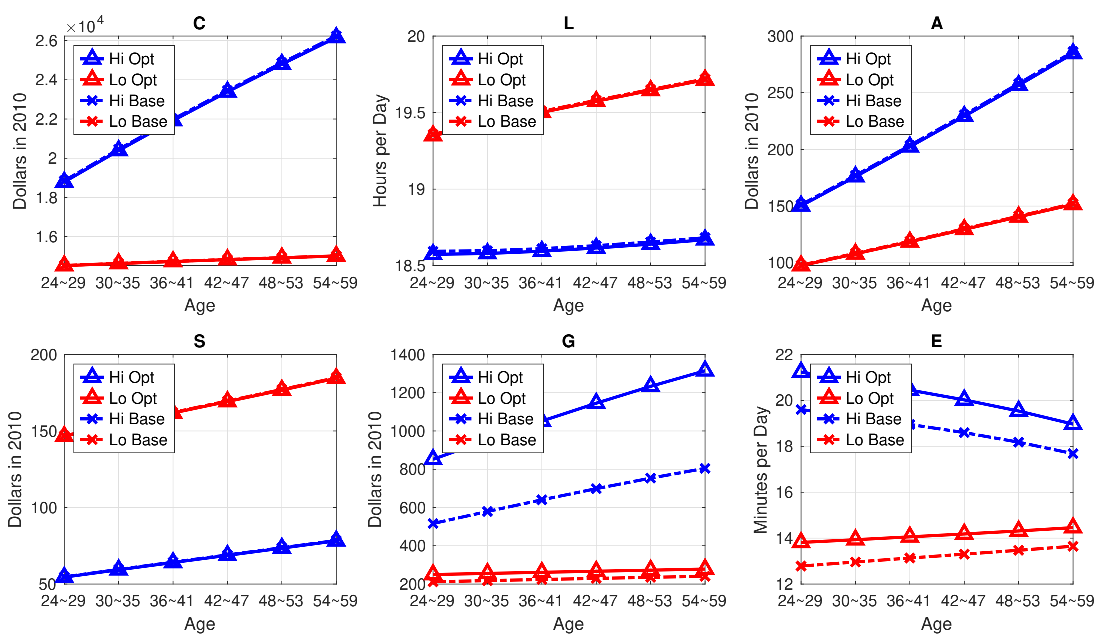


Figure 11: Control Variables for LoEd_2



may be hard to adjust in the reality, but the implications do not differ by much. The decomposition analyses performed in subsection 5.1 could also be applied here by using comparing Table 12 with Table 13 and Table 14.

6 Conclusion

This paper has constructed an overlapping generation model of working age with endogenous health production function of exercise time use, alcohol consumption, and cigarette consumption to compare the welfare effects of optimal subsidization of sports goods to those of optimal taxation on alcohol and cigarette. The welfare gain from optimal subsidization of sports goods is \$146.08 per household every year, about 16 times higher than that from optimal taxation on alcohol and cigarette. The former decreases the aggregate medical expenditure by 3.2%, while the latter only by 0.2%.

Although the effects of sports goods subsidy turns out to be the largest among all forms of taxation discussed, the full effects of sports goods subsidy have to wait until the economy approaches the steady state as they more involve the health production. It is possibly due to this reason that legislation on sports goods subsidy hardly passes in the US Congress, as it could generate net loss in some initial stages of transition. Also the COVID situation could lower the efficacy of sports goods subsidization and makes the legislation less likely to happen.

Nonetheless, there are margins of additional effects. The lower bound of sports subsidy rate that we have set by setting the Pareto weight of low education group to 1 could increase if we consider a progressive taxation scheme. Our model assumed a uniform sales tax rate as the main source of tax revenue, but if we allow the progressive income tax system to compensate the negative distributional effect of the subsidy, the lower bound could be higher. Furthermore, we have only considered the medical expenditure related externality, but if we also consider work related insurance such as disability insurance and ADAAA system as in Cole et al. (2019), the role of the taxation/subsidization could be bigger.

A Appendix

A.1 Retirement Parameters

Table 15: Health Discount Factor : Retirement

Age	60-65	66-71	72-77	78-83	84-89
HighEdu	0.915	0.909	0.895	0.882	0.855
LowEdu	0.906	0.901	0.890	0.881	0.864

Table 16: Retirement Health Transition : High Education

	Dependent variable:				
	Future Health Status				
	60-65	66-71	72-77	78-83	84-89
	(1)	(2)	(3)	(4)	(5)
Constant	$1,449.867^{***}$	$1,418.470^{***}$	$1,421.113^{***}$	$2,119.411^{**}$	$3,262.236^{*}$
	(273.587)	(369.543)	(503.828)	(838.045)	(1,851.835)
m	1.169^{***}	1.218^{***}	1.246^{***}	1.192^{***}	1.061^{***}
	(0.045)	(0.058)	(0.078)	(0.128)	(0.290)
m^2	-0.00001^{***}	-0.00001^{***}	-0.00002^{***}	-0.00001^{***}	-0.00001
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00001)
Observations	5,746	3,830	2,161	948	273
R^2	0.534	0.507	0.499	0.465	0.390
Adjusted R^2	0.534	0.507	0.498	0.464	0.385
Residual Std. Error	3,494.641	3,651.687	3,728.884	3,934.396	4,478.662
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 17: Retirement Health Transition : Low Education

	Dependent variable:				
	Future Health Status				
	60-65	66-71	72-77	78-83	84-89
	(1)	(2)	(3)	(4)	(5)
Constant	$2,303.464^{***}$	$2,474.845^{***}$	$2,732.106^{***}$	$3,168.679^{***}$	$4,017.736^{***}$
	(234.294)	(287.879)	(401.994)	(630.690)	(1,244.085)
m	1.115^{***}	1.124^{***}	1.127^{***}	1.112^{***}	1.011^{***}
	(0.035)	(0.042)	(0.057)	(0.089)	(0.179)
m^2	-0.00001^{***}	-0.00001^{***}	-0.00001^{***}	-0.00001^{***}	-0.00001^{**}
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00001)
Observations	10,365	7,631	4,425	1,985	623
R^2	0.497	0.473	0.443	0.405	0.329
Adjusted R^2	0.497	0.473	0.443	0.404	0.327
Residual Std. Error	4,028.910	4,147.351	4,302.229	4,473.474	4,567.324
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 18: Logistic Regression of Exit Probability : High Education

	Dependent variable:				
	Outcome Deceased				
	60-65	66-71	72-77	78-83	84-89
	(1)	(2)	(3)	(4)	(5)
Constant	-4.369^{***}	-3.621^{***}	-2.968^{***}	-2.248^{***}	-1.720^{***}
	(0.200)	(0.224)	(0.263)	(0.342)	(0.547)
m	0.0003^{***}	0.0002^{***}	0.0002^{***}	0.0002^{***}	0.0002^{***}
	(0.00003)	(0.00003)	(0.00004)	(0.00005)	(0.0001)
m^2	-0.000^{***}	-0.000^{**}	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	7,192	5,133	3,249	1,747	751
Log Likelihood	-3,117.988	-2,577.799	-1,865.044	-1,109.444	-457.344
Akaike Inf. Crit.	6,241.976	5,161.597	3,736.088	2,224.888	920.687

Note: *p<0.1; **p<0.05; ***p<0.01

Table 19: Logistic Regression of Exit Probability : Low Education

	Dependent variable:				
	Outcome Deceased				
	60-65	66-71	72-77	78-83	84-89
	(1)	(2)	(3)	(4)	(5)
Constant	−3.053***	−2.585***	−2.008***	−1.276***	−0.061
	(0.121)	(0.132)	(0.155)	(0.205)	(0.331)
m	0.0002***	0.0002***	0.0001***	0.0001***	0.00004
	(0.00002)	(0.00002)	(0.00002)	(0.00003)	(0.00005)
m^2	−0.000***	−0.000**	−0.000	−0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	14,761	11,671	7,851	4,526	2,169
Log Likelihood	-8,184.943	-6,930.137	-5,012.073	-2,939.173	-1,243.465
Akaike Inf. Crit.	16,375.890	13,866.270	10,030.150	5,884.345	2,492.930

Note: *p<0.1; **p<0.05; ***p<0.01

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