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Health Capital Taxation*

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ABSTRACT

This paper studies the design of health care and tax policies in a quantitative macroeconomic model. We theoretically and quantitatively characterize the optimal taxation on consumption, health investments, earnings and capital investments. Policies are constrained due to private information with respect to shocks to household labor productivity and health status. We compare the results to actual policies and household allocations in the Netherlands, a country with a single-payer system but vast differences in health expenditures and mortality rates across income groups.

*The views expressed here are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

1. Introduction

In many countries, health expenditures are large and increasing, and there are vast differences in health expenditures and mortality rates across income groups. We study how to optimally allocate health resources in an economy with privately observed health and labor productivity shocks.

Modeling health is a complex task since health capital affects both the agent's utility function, as well as the agent's budget constraint. In our environment, we incorporate the accumulation of health capital to incorporate two of these effects. First, a low level of health capital decreases survival probabilities. Second, as in Grossman (1972), an individual in bad health does not derive the same utility from leisure because he has less healthy time available.

We characterize optimal health and tax policies in an overlapping generations economy subject only to the constraint that the policies cannot be a function of the realization of idiosyncratic shocks. Taxes cannot be explicitly conditioned on shocks because these are assumed to be unobserved by the tax authority. We compare the resulting constrained efficient allocations and policies to actual outcomes in the Netherlands. The Netherlands is a country with a single-payer system but vast differences in health expenditures and mortality rates across households, even if we condition on age.

In this draft, quantitative results for a three-period life cycle are used to describe the basic forces at work in our model. Although the model is not fully calibrated to the micro- and macro-data of the Netherlands, we discuss potential counterfactual relations between income and health expenses and in mortality probabilities, which need to be addressed in the full quantitative model. We then contrast the competitive equilibrium allocation and the constrained efficient allocation describing precisely how a planner would incentivize individuals with high productivity levels and good health and redistribute to those households with low productivity levels and poor health.

Finally, we show in our simple example that welfare gains are achievable.

There is a large and growing literature focused on health policy reform, mostly in the United States. The main programs being evaluated are Medicaid for the poor, and Medicare for the elderly. (See, for example, Attanasio, Kitao, and Violante (2010), Conesa, Costa, Kamali, Kehoe, Nygard, Raveendranathan, and Saxena (2017), De Nardi, French, and Jones (2016), French and Jones (2011), and Hansen, Hsu, and Lee (2014)). More recently, there has been considerable attention on the Affordable Care Act. (See, for example, Aizawa and Fang (2015), Brügemann and Manovskii (2010), Jung and Tran (2016), Nakajima and Tuzemen (2017), Pashchenko and Porapakkarm (2013), and Tsujiyama (2015)).

There are several advantages to working with data from the Netherlands rather than the United States. First, the Netherlands is a single-payer system with virtually universal health insurance coverage and, therefore, we can easily separate the financing of health insurance and health services (for example, doctor visits and hospital stays). Second, health insurance is not included with tax-deferred employee benefits, something that complicates the analyses of both health and tax reform for the United States. Finally, we have access to detailed micro data on health expenditures as well as other details for households that are not available in the United States.

2. Data

In this section, we describe key data moments for the Netherlands. These moments will be the basis for parameterizing our theory.

A. Health Statistics

We first document the dispersion in health expenses and mortality rates across income and age groups. In Figure 1, we present the life cycle pattern of average health expenditures for a median income individual, and two income deciles. To illustrate, the green dotted line gives health expenditures for individuals whose one-year lagged income is between the tenth and twentieth percentile of the cohort-specific income distribution. As we expected, health care expenses increase over the life cycle. More surprisingly, health care expenses for the income-poor exceed health care costs for the income-rich by an average of one thousand euro every year. This dispersion in health care costs is observed across age groups.

In addition, there is great dispersion in life expectancy across age and income groups. Figure 2 shows the mortality probability for males by age and income groups.[1] The figure shows that individuals in higher quantiles of the income distribution have lower mortality probabilities than individuals in lower quantiles of the income distribution, across all age groups. To put numbers on these differences, consider a high-income and a low-income male that are 50 years old. The high-income individual faces a mortality probability of 0.9% until 55, while the low-income individual's mortality risk equals 3.5%. At age 65, the high-income individual faces a mortality probability of 4.4% against 10.8% for a low-income individual.

B. Policy Environment

In this section, we describe the policy environment for the Netherlands. This policy is an input to our decentralized model economy. We discuss taxation of income and wealth, as well as policies related to pensions and health.

Taxation of Income

The tax code consists of two parts: a schedule for the marginal income tax rates for different sources of income, and a schedule for tax credits. Both parts differ between workers and retirees. When modeling the income tax schedule, we introduce a separate schedule for households above

[1] The life expectancy for females is higher across income and age groups, implying lower mortality probabilities. The qualitative patterns are the same for both genders.

the retirement age. Here, we report numbers for 2017.

The marginal rates are summarized in Table 1. There are three sets of rates depending on the category of income. The top panel of Table 1 shows rates applying to labor earnings such as the compensation of employees, entrepreneurial profits, and pension income. In this case, there are four income brackets, with the lowest incomes facing a marginal rate close to 37 percent and the top bracket at 52 percent. In retirement, households with income below 34 thousand euro have considerably lower tax rates, while the higher income households face the same marginal rates as when they were of working age. The second income category is income on "significant share holdings," which means income from owning more than 5 percent of shares in a firm. Significant share holdings generate dividend and capital gains, which are both taxed at a flat rate of 25 percent. The remaining category is income generated by assets such as deposits, shares, and real estate holdings (excluding the primary residence). Above a threshold wealth level, the returns generated by these assets are taxed at a 30 percent rate. To calculate the returns on assets, the tax authority determines a baseline rate of return. The exemption level is 25,000 euro for single households, and 50,000 euro for joint tax filers. The exemption level varies across tax years.

The income tax schedule is complemented with a number of different tax credits. Tax credits reduce the amount of taxes households pay. We describe four important tax credits: a general tax credit, an earned income tax credit, a child tax credit, and a retiree tax credit. A general tax credit applies to labor earnings and is both income- and age-dependent. The top panel of Table 2 presents the general tax credits. Working age households receive a tax credit of 2,254 euro when their labor earnings are below 19,982 euro. Above this income level, the tax credit phases out linearly until reaching zero at 67,068 euro. To households above the retirement age, a tax credit of 1,151 euro applies. The tax credit for retirees also phases out linearly between 19,982 and 67,068 euro.

Similar to the United States, the Netherlands has an earned income tax credit and a child tax credit. The earned income tax credit is targeted at low- to moderate-income working households. The amount of the tax credit is a piecewise-linear function of the amount of labor income. In the second panel of Table 2, we describe this piecewise-linear function. The child tax credit applies to households with children below the age of 12. The amount of the tax credit depends on the income of the household member with the lowest labor earnings. A household with children below the age of 12 receives a tax credit of 2,778 euro when labor earnings of the low-income parent exceeds 33,065 euro.

Finally, households above the retirement age may qualify for an old age tax credit. Pensioners with income below 36,057 euro per year receive an old age benefit of 1,292 euro, while households above this cutoff point receive 71 euro per year.

What is relevant for our theory is the mapping from different income tax and credit schedules to an effective income tax rate. To illustrate how we compute this, consider a couple of working age without children. Suppose the household has an outstanding mortgage balance of 100 thousand euro at a 4 percent annual interest rate, 40 thousand euro in assets, and no significant share holdings. The couple enjoys a home mortgage interest deduction of 4 thousand euro, and does not qualify for the old age tax credit and the child tax credit. Total income taxes are determined by the marginal tax schedule, the general tax credit, and the earned-income tax credit. Figure 3 illustrates the effective income tax schedule faced by this household as a function of labor income. The household faces a progressive income tax schedule, the average tax rate increases with income. When the couple earns 30 thousand euro, they pay 8,440 euro in taxes. This amounts to an average tax rate of 28.1 percent. When the household earns 70 thousand euro, they pay 25,311 euro in taxes, implying an average tax rate of 36.2 percent.

Pension System

The pension system is built on three pillars: a government pension, a collective employer-based pension, and private savings. The system combines private provisions, with pay as you go (for public pensions), as well as a collective savings scheme (for employer-based pensions).

The first pillar of the Dutch pension system is a public pension, or *Algemene Ouderdomswet* (AOW) pension. The AOW is implemented to provide a minimum level of income to all pensioners. Every individual who lives or works in the Netherlands builds up a general public pension. In particular, every individual earns 2 percent of the maximum AOW amount for every year that they reside in the Netherlands before the legal retirement age. The 2 percent is foregone each year that an individual resides outside of the Netherlands. Note, however, that an individual does not have to work to build up an AOW pension. In other words, the public pension is a transfer.

The level of the AOW pension is determined in relation to the legal minimum wage. A reasonable rule-of-thumb is that single households receive net AOW pension equal to 70 percent of the net minimum wage, while couples jointly receive 100 percent of the individual net minimum wage. For 2017, this implies that a retired couple receives a maximum gross AOW pension income of 20,613 euro.

The AOW pension system is pay-as-you-go, and paid through AOW pension premia under the income taxes in labor earnings discussed above. Households in retirement do not pay AOW premia, which explains the lower labor earnings marginal tax rate on income below approximately 34 thousand euro.

The second pension system pillar is employer-based, with pension premia and payouts that vary with lifetime earnings. The employer-based pension generally aims to provide households a replacement rate of 75 percent of average annual earnings upon retirement.[2] This replacement

[2]This system is classified as a *middelloonsystem*. To reach the 75 percent replacement rate upon retirement, a premium of 2.25 percent is generally adopted. In some occasions, the target rate is 70 percent on the worker's final

rate includes the public pension. Individual do not have an employer-based pensions if they never worked, when they are self-employed, or in case their employer did not arrange a pension. More than 90 percent of all firms provide pension arrangements for their employees.

Under the employer-based pension system, an employer pays more than half of the pension premia into a collective investment fund, with the remainder being contributed by the employee. The provision of pensions through collective investment funds by employers and employees is based on industry-wide or firm-specific agreements (for example, in case of large firms such as Philips and Shell). The employer-based pension is deferred income for employees, the employer directly contributes their share of the premium into the investment entity.

Health Care System

In this section, we discuss the structure of the health care system as well as health insurance subsidies for low-income households. The health care system can be summarized in two pieces of legislation: the Long-Term Care Act (or *Wet Langdurige Zorg* (WLZ)) and the Health Insurance Act (or *Zorgverzekeringswet* (ZVW)).

The WLZ provides health care insurance for expenditures incurred by the indigent elderly, psychiatric patients, and disabled citizens. This component of the health insurance system is financed through the income tax system. Recipients have to pass an examination in order to qualify for these benefits. The benefits finance long-term treatments. Most commonly, recipients live in care facilities.

The ZVW is mandatory health insurance for primary care. The primary insurance package is identical for all individuals. Every year, the government determines the expenses the insurance package covers, and the level of the minimum deductible. The policy holder may negotiate a higher deductible with a government-approved insurance company. In 2017, the minimum deductible

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is set at 385 euro. The individual insurance premium costs approximately 1400 euro per year. Importantly, health insurers are not permitted to discriminate against policy holders by age or health status or to deny individuals primary health insurance. Children under the age of 18 are covered under the policy of their parents.

Primary health insurance provided under ZVW covers expenditures on visits to a general practitioner, hospital care, prescription drugs, basic dental care, pre- and postnatal care, primary physiotherapy, and therapeutic products. We consider these expenditures to be of key importance for individuals who are employable. Our data describes the total expenditures incurred within the ZVW program person by person. The total costs we observe includes the deductible.

Households incur out-of-pocket expenses for primary health care above the deductible for some procedures to which a co-pay applies. In the decentralized model environment, the co-pay ensures that household demand for health commodities is interior. The co-pay applies to subcategories of prescription drugs, dental care, pre- and postnatal care, and therapeutic products. To illustrate, households pay 57 for glasses and contacts lenses, 25 percent of the costs for dentures, and all costs above 431 euro for a wig.

Low-income and low-asset households qualify for government support to pay for their primary health insurance. A household with annual income below 20 thousand euro receives 170 euro per month, or 2040 euro. The amount received decreases in household income. When household income is 25 thousand euro the health subsidy is 115 euro, when household income is 30 thousand euro the subsidy amounts to 59 euro. When household income exceeds 35 thousand dollar, no health subsidy is received. The health credit is asset-tested: when household wealth exceeds 132,752 no health subsidy is received.

C. Aggregate Data

The parameterization of the model must also achieve consistency at the aggregate level. More specifically, we are interested in aligning the model with national income and product accounts, fixed assets, flow of funds, and aggregate labor market statistics.

In Table 3, we report components of gross domestic product and income based on data from the Dutch Bureau of Statistics. These data have been averaged over the period 2000-2010. Incomes are categorized as labor or capital. Labor income includes compensation of employees and a fraction of proprietors' income. Capital income includes profits from businesses other than proprietors, the remaining fraction of proprietors' income that is not assigned to labor income, indirect business taxes, and consumption of fixed capital. We make three adjustments to both income and product. We subtract sales taxes from indirect business taxes and consumption (which is recorded at purchasers' prices), recategorize consumer durables as fixed investments, and include a service flow for government investment.

Table 4 reports the total net stock of capital including consumer durables, land, inventories, and non-extracted oil and gas. The total stock is roughly 5.3 times adjusted GDP, with most in fixed assets and land. In Table 5, we report valuations of household net worth and government debt, which are close to 4 times GDP and 0.6 times GDP, respectively.

Statistics for the population, employment, and hours are shown in Table 6. These data are averaged over the period 2000-2010. The population of 16 to 64 is close to 11 million, with a growth rate of 0.33. Aggregate hours per person are 1135 annually or 21.8 percent of available time (estimated to be 100 hours per week).

3. Theory

In this section, we describe two economic environments. The first is intended to be compared to data from the Netherlands. For this environment, we solve a competitive equilibrium in which households take health and tax policies as given and optimally choose how much to consume, work, and spend on improving their health status. The second environment is a planning problem in which the planner minimizes costs of providing allocations of consumption, output, and health capital subject to ex-ante welfare and incentive constraints. The constrained efficient allocation of the planning problem can be decentralized and compared to the predictions for the competitive equilibrium parameterized to the Netherlands.

In both environments, agents live for a maximum of T years and retire in year T_R. They are subject to idiosyncratic health and labor productivity risk. The realizations of the labor productivity shock and the health shock are captured by $s = (\theta, \varphi)$, which is assumed to follow a Markov process. The corresponding probability of being type s is given by $\mu(s)$. The survival probability from period $t-1$ to t, which we denote by p_t is determined by the individual's health capital stock h in period $t-1$, that is, $p_t = p_t(h(s^{t-1})$ and the health stock in turn depends on the history of unobserved shocks to labor productivity θ and to health φ, that is, $h_{t-1} = h(s^{t-1})$, where $s^{t-1} = (s_0, s_1, \ldots, s_{t-1})$.

Preferences are given by

$$U(c, h, y) = \mathbb{E}_0 \sum_{t=1}^{T} \beta^{t-1} P_t u(c_t, h_t, y_t; \theta_t, \varphi_t)$$

where $P_t = \Pi_{s=1}^{t} p_s$ and an allocation of consumption, health, and output is given by $\{c, h, y\} \equiv \{c(s^t), h(s^t), y(s^t)\}$. The law of motion for health capital is given by

$$h_t = (1-\delta) h_{t-1} + m(e_t),$$

where e_t is expenditures on health and $m(\cdot)$ governs the impact this spending has on health status. We assume agents begin life with the same health status h_0.

A. Competitive Equilibrium

In this section, we present a competitive equilibrium model for the Netherlands. Our goal is to construct a competitive environment which is able to replicate key features of the data we discussed in Section 2. We use our model environment to estimate parameters of the production function, and the utility function.

The general equilibrium model features households that face idiosyncratic labor productivity and health risk, competitive firms, and a government. Households have access to a risk-free asset that provides actuarially fair returns. We abstract from aggregate shocks. In this section, we describe the household problem, the firm problem, and the government, and we define equilibrium.

Households

In the initial stage of the life cycle, households enter the labor market. At this stage, households are identical with respect to their initial assets a_0, initial health capital h_{-1}, and levels of labor productivity θ_0 and health shocks φ_0.

The dynamic programming problem that households solve in all years prior to retirement ($t \leq T_R$) is given by

$$V_t(a_t, h_{t-1}; s_t) = \max \; u(c_t, h_t, y_t; s_t) + \beta \mathbb{P}(h_t) \sum_{s_{t+1}} \mu(s_{t+1}|s_t) V_{t+1}\left(a_{t+1}, h_t; s_{t+1}\right)$$

$$\text{subject to} \qquad c_t + e_t + \mathbb{P}(h_t) a_{t+1} = (1 + r(1-\tau_a))a_t + (1-\tau_y) w y_t + T_t^w + T^e(e_t) \; ,$$

and the law of motion for health capital. Workers earn interest on their savings, are remunerated with labor earnings, and receive age-dependent transfers T_t^w, as well as health care transfers T^e. The health care transfers depend on the household's health care expenditures. Earnings are taxed at linear rate τ_y, the returns on assets are taxed at linear rate τ_a. Workers use the available funds to finance consumption, and health care expenditures, and to acquire net assets.

When workers retire, their effective labor supply is set to zero, $y_t = 0$. Hence, when workers retire, they only experience health shocks φ_t and therefore, $s_t = (0, \varphi_t)$. The problem that households solve in retirement ($T_R < t < T$) is given by:

$$V_t(a_t, h_{t-1}; s_t) = \max\ u(c_t, h_t; s_t) + \beta \mathbb{P}(h_t) \sum_{s_{t+1}} \mu(s_{t+1}|s_t) V_{t+1}\left(a_{t+1}, h_t; s_{t+1}\right)$$

$$\text{subject to} \qquad c_t + e_t + \mathbb{P}(h_t) a_{t+1} = (1 + r(1-\tau_a)) a_t + T_t^r + T^e(e_t)\ ,$$

and the law of motion for health capital. We impose that households choose non-negative assets when they reach period T, $a_{T+1} \geq 0$.

Firms

Firms operate in a perfectly competitive market using a constant returns to scale production function $F(K, Y)$. Given a wage w, and a rental rate for capital r, firms choose capital and labor to solve a static problem:

$$\max\ F(K, Y) - wY - rK\ .$$

Government

The government runs a balanced budget. Government income is generated by taxes on labor earnings and asset income. The government uses this income to finance transfers to workers, transfers to retirees, health care transfers, and an exogeneous expenditure level G. This yields the following government budget constraint:

$$\sum_{s^t} \mu(s^t) P_t\left(s^{t-1}\right)\left(T_t^r + T_t^w + T^e\left(e_t(s^t)\right)\right) + G = \sum_{s^t} \mu(s^t) P_t\left(s^{t-1}\right)\left(\tau_y w y_t(s^t) + r\tau_a a_t(s^t)\right)\ .$$

Equilibrium

Given a tax policy $(T_t^r, T_t^w, \tau_y, \tau_a, T^e.G)$, a stationary equilibrium is a sequence of allocations $\{c_t, e_t, a_t, y_t\}$, and prices $\{w, r\}$, such that: (i) the allocations solve the household problems; (ii) markets clear, (iii) the government budget constraint is satisfied.

B. Planner Problem

In this section, we present the planning problem in which the planner minimizes costs of providing allocations of consumption, output, and health capital subject to ex-ante welfare and incentive constraints.

As is well known from the revelation principle, the outcome of any equilibrium strategy profile of any mechanism can be implemented as the truth-telling equilibrium of a direct mechanism. In the direct mechanism we consider, agents report $r_t \in \Theta \times \Phi$ regarding s_t. A report strategy is denoted $\sigma \equiv \left\{\sigma_t(s^t)\right\}_t$, where $\sigma_t : s^t \to r_t$, and Σ is the set of reporting strategies. Every reporting strategy σ has a corresponding implied history of reports denoted by $\sigma^t(s^t) = (\sigma_1(s^1), \ldots, \sigma_t(s^t))$. For a given allocation, when households report truthfully, their continuation value after history s^t is given by

$$V(s^t) = u\left(c(s^t), h(s^t), y(s^t); s_t\right) + \beta p_{t+1}\left(h(s^t)\right) \sum_{s_{t+1}} \mu^t\left(s_{t+1}|s_t\right) V(s^{t+1}) \,, \qquad (1)$$

for all $t = 1, \ldots, T$ with $V(s^{T+1}) = 0$. We refer to $V(s^t)$ as the equilibrium continuation utility. For any reporting strategy $\sigma \in \Sigma$, the continuation value is

$$V^\sigma(s^t) = u\left(c(\sigma^t(s^t)), h(\sigma^t(s^t)), y(\sigma^t(s^t)); s_t\right) + \beta p_{t+1}\left(h(\sigma^t(s^t))\right) \sum_{s_{t+1}} \mu^t\left(s_{t+1}|s_t\right) V^\sigma(s^{t+1}) \,, \qquad (2)$$

for all $t = 1, \ldots, T$ with $V^\sigma(s^{T+1}) = 0$. An allocation in this environment is incentive compatible if and only if

$$V(s^t) \geq V^\sigma(s^t) \ ,$$

for all s^t. Furthermore, an allocation is incentive compatible when truth-telling is an equilibrium strategy. We denote the set of all incentive compatible allocations by X_{IC}.

We analyze a cohort profit maximization problem.[3] For the cohort problem, the value of a unit of production in the next period is given by $q \equiv 1/R$. For period t, the appropriate discount factor is thus q^{t-1}.

The relevant profit function is then the expected present value of resources:

$$\Psi\left(\{c, e, y\}\right) = \sum_{t=1}^{T} \sum_{s^t} q^{t-1} \mu(s^t) P_t(s^{t-1}) \big(y(s^t) - c(s^t) - e(s^t)\big) + A_0 \ ,$$

where A_0 is the net present value of government expenditures.

An incentive compatible allocation is efficient if and only if there exists no alternative incentive compatible allocation that generates greater profits and gives greater utility. Thus, there does not exist $\{\hat{c}, \hat{h}, \hat{y}\}$ such that $\Psi(\{\hat{c}, \hat{h}, \hat{y}\}) \geq \Psi\left(\{c, h, y\}\right)$ and $U(\{\hat{c}, \hat{h}, \hat{y}\}) \geq U(\{c, h, y\})$, with one inequality being strict.

Efficient allocations solve the following program:

$$\Pi(\mathcal{V}_0) \equiv \max_{\{c,h,y\}} \ \Psi\left(\{c, h, y\}\right)$$

$$\text{s.t. } U\left(\{c, h, y\}\right) \geq \mathcal{V}_0$$

$$\left(\{c, h, y\}\right) \in X_{IC}$$

[3] In a separate appendix, we show that studying the cohort problem is without loss of generality. The solution to the cohort profit maximization problem is a solution to the planner problem for a stationary environment.

where $\mathcal{V}_0$ is the 'endowed' expected utility level.[4] The planner has to ensure that ex-ante expected utility exceeds $\mathcal{V}_0$. Below, $\mathcal{V}_0$ is set such that $\Pi(\mathcal{V}_0) = 0$.

4. Quantitative Results

In this section, we describe quantitative results for the competitive equilibrium and for the planning problem in a three-period life-cycle model.[5] We strip down our model to provide insights into the mechanism of our model and to illustrate how we relate the competitive equilibrium to the planning problem.

A. Parameters

The life-cycle stages of the three-period model capture the periods when agents are young workers, older workers, and retirees. In this version of our model, households face labor productivity risk when they are old workers, and risk detrimental health shocks when they are old workers, as well as when they are retired. The health shocks and the labor productivity shocks are assumed to be independently distributed across time. We use index $t = 0, 1, 2$ to denote the three stages of the life cycle.

Young workers are all identical in terms of their shock vector, which we denote s_0. Older workers have productivity shocks that are either high H or low L and health shocks indicating that they are either injured I or not injured N. Retirees do not work but face an idiosyncratic health shock that is I or N.

As a first example, we use logarithmic preferences:

$$u(c, h, y; \theta, \varphi) = b + \gamma \log(c) + (1 - \gamma) \log(\varphi h - y/\theta),$$

[4] The formulation of the planner problem is closely related to the planner problems in Farhi and Werning (2013), Golosov, Troshkin, and Tsyvinski (2016), and Stantcheva (2017).

[5] In the next draft, we will report results for the full T-period life-cycle model parameterized to match data from Section 2.

where the constant b is added to ensure positive utility. Adding a positive constant to flow utility eliminates the perverse incentive to reduce the probability of survival.[6] In the retirement period, utility is given by:

$$u(c, h, 0; 0, \varphi) = b + \gamma \log(c) + (1 - \gamma) \log(\varphi h),$$

since effective labor supply is zero. Thus, the only allocations for the last period are consumption and health capital. Note that period utility can therefore be written separably in the health shock.

To conduct our quantitative exercise, we map the actual policies for the Netherlands, which we discussed Section 2, to our model economy. The income tax code in Figure 3 is well-approximated by an affine function. The slope of the function is 0.4, while the intercept is minus 1,500 euro.[7] For our simple quantitative competitive equilibrium for the Netherlands, we separate three stages in the life cycle: 25 to 45 years, 45 to 65 years, and 65 to 85 years. We take the relevant survival probabilities to be survival probability between 35 and 55, and between 55 and 75. The model survival probability between ages 35 and 55 is identical across individuals, the survival probability between age 55 and 75 differs between income groups. Using the mortality probabilities by age displayed in Figure 2, the relevant data moments are survival probabilities of 96.4 percent for the young, 73.4 percent for low-income workers, and 81.5 percent for high-income workers.

The specific parameter values that we choose are as follows. The initial productivity level θ_0 and health shock are both normalized to 1. The old workers face values of $\theta_L = 1$ or $\theta_H = 1.5$, implying a 50 percent wage growth for high types. The health shock of non-injured individuals remains at 1. When high type is injured, the productivity is identical to the the productivity of a low type that is not injured, $\varphi_I = \theta_L \varphi_N / \theta_H$. This means that the agent loses a third of his health capital. Between the first and second period, the transition probabilities to four possible new states

[6]This is similar to Hall and Jones (2007) and Ales, Hosseini, and Jones (2014).

[7]To simplify the exposition of the model mechanism, we abstract from introducing the pension system, and the health care system.

are given by $\mu(H,N) = \mu(L,N) = .475$ and $\mu(H,I) = \mu(L,I) = .025$. Injury is more likely when older, with the probability of φ_I equal to 0.3.

The preference weight governing the value of life is $b = 2.5$, and the preference weight on consumption is $\gamma = 1/3$. The interest rate is 4 percent annually (and, therefore, $\beta = 0.96^{20}$). The wage rate is $w = 1$. The initial health capital stock is $h_{-1} = 1$, implying that agents have full time at their disposal, and the annual depreciation rate is 10 percent (or $1 - 0.9^20$). The tax rate on labor earnings is $\tau_y = 0.4$, the rate on assets is $\tau_a = 0.15$, there is a transfer payments to all individuals equal to 0.1 and the government spending is found residually and equal to 0.005.

We choose the following functional forms for the survival probabilities and the medical expenditure function:

$$p(h) = 1 - \exp\{-\alpha_h h\}$$

$$m(e) = \alpha_m e^{\rho}$$

with $\alpha_h = 1.5$, $\alpha_m = 1$ and $\rho = 0.05$.

B. Numerical Results

We describe and contrast the competitive equilibrium allocation, and the constrained efficient allocation.

Table 7 summarizes our quantitative solutions. We present the equilibrium allocation for the decentralized environment in the left-hand panel, and the equilibrium allocation for the constrained efficient allocation in the right panel. For each specification, we provide the allocation of consumption, health investments, earnings, hours worked, and the mortality rate.

The left-hand panel of Table 7 describes the equilibrium allocations for the decentralized economy. The columns present the allocations for consumption, health investments, earnings, hours, and the mortality probability, respectively. Along the rows, we list allocations for different types.

In providing intuition for the allocations, we work from the final period to the first stage. First, we observe that allocations in the final stage do not depend on the period realization of the health shock. This result follows from the fact that we used logarithmic preferences over leisure, which implies additively separable health shocks. In this case, the injured retirees are worse off, as low health shocks reduce period utility. Given that health shocks are independently and identically distributed across time, the dispersion in household allocations persists from the intermediate period.

Next consider the consumption level for old workers in the intermediate period. Their consumption level exceeds that of retirees. From the Euler equation, it is easy to establish that the declining trend in consumption is driven by the positive asset tax. Note that consumption, health expenditures and earnings are strictly monotonic in effective types. The high productivity, non-injured type works and earns most, which is used to consume most, and invest most in health care. As a result, the high type faces the lowest mortality probability, and therefore have the highest life expectancy.

In the initial period, all households are identical. Because of the government's use of asset taxes, the households are incentivized to consume early. Households spend roughly 20 percent of their time working, which is comparable to what we observe in the data. To finance consumption and health investments, households borrow when they are young.

Later, we will use microdata for the Netherlands to explore the relation between health expenses, age, and mortality. The current model predicts counterfactual relations between income and health expenses and in mortality probabilities, which need to be addressed in the full quantitative model. First, we observe that the difference in mortality probabilities in the model, although qualitatively correct, is much smaller than the difference observed in the data. Furthermore, the survival probability for young workers is too high. Second, the model generates a counterfactual relation between income and health expenses. This result is driven by the preference structure and the health accumulation technology. In our model, the health technology implies that the returns to health spending are larger for healthy individuals. To match the equilibrium allocation to the data, we require a mechanism that ensures that the returns to health expenditures are significantly larger for low income earners. This requires two changes: we model curative health, following the lines of Ozkan (2014), and we explore the relation between income and health shocks.

We next compare the competitive equilibrium allocation against the constrained efficient allocation. The allocations for the constrained efficient allocation are described in the right-hand panel of Table 7. As we noted earlier, since we assume logarithmic preferences with respect to consumption, the allocations in the final stage do not depend on the period realization of the health shock. In the final period, all incentive constraints are slack because the privately observed health shock enters separably.

In terms of quantities, the consumption and health expenses are roughly 50 percent larger than in the competitive equilibrium allocation. Moreover, note that the consumption levels in the first and intermediate periods are identical to the consumption levels in the final period. The constrained efficient allocation features an undistorted intertemporal margin for older workers. This observation suggests that the positive asset taxes in the competitive equilibrium are a source of inefficiency.

By comparing the constrained efficient allocations for older workers to the corresponding allocations for the competitive equilibrium, we learn how the social planner redistributes from high productivity, non-injured households to low productivity, injured households. In the constrained efficient allocation, the planner incentivizes high productivity, non-injured households to produce more resources. Some of these additional resources are used to prevent the high productivity, non-injured agents from mimicking other types, and part is used to redistribute to types that are worse off. In particular, the planner redistributes to the low productivity, injured households. In the decentralization of the constrained efficient allocation, these agents enter the intermediate period with debt holdings and they will only consume in retirement, yet the implementation of the social system enables them to run another period deficit. The less fortunate are net recipients of resources in every period.

In the initial period, the planner prescribes that the agents produce resources. The planner has two motivations for doing so. First, it is relatively cheap to promote production in the initial stage of the life-cycle, because doing so does not affect any incentive constraint. Second, the planner wants to increase health expenditures to promote survival probabilities of the households, and to relax incentive constraints for old workers.

To conclude our discussion of the numerical results, we explain how we will calculate of the welfare differences between the two economies. In particular, we calculate the percentage increase in consumption that a household in the competitive equilibrium has to receive in order to be indifferent between living in the competitive economy and in the constrained allocation. Note that it is important to specify the direction of comparison due to the differences in survival probabilities.

5. Conclusion

In this paper, we study the optimal design of health and tax policies for an overlapping generations economy. We have characterized the optimal taxation on consumption, health investments, earnings and capital investments taking into account that the provision of social insurance is constrained due to private information with respect to shocks to household labor productivity and their health status. We compared the equilibrium allocation under the current policy to the constrained efficient allocation and observed that welfare gains are achievable.

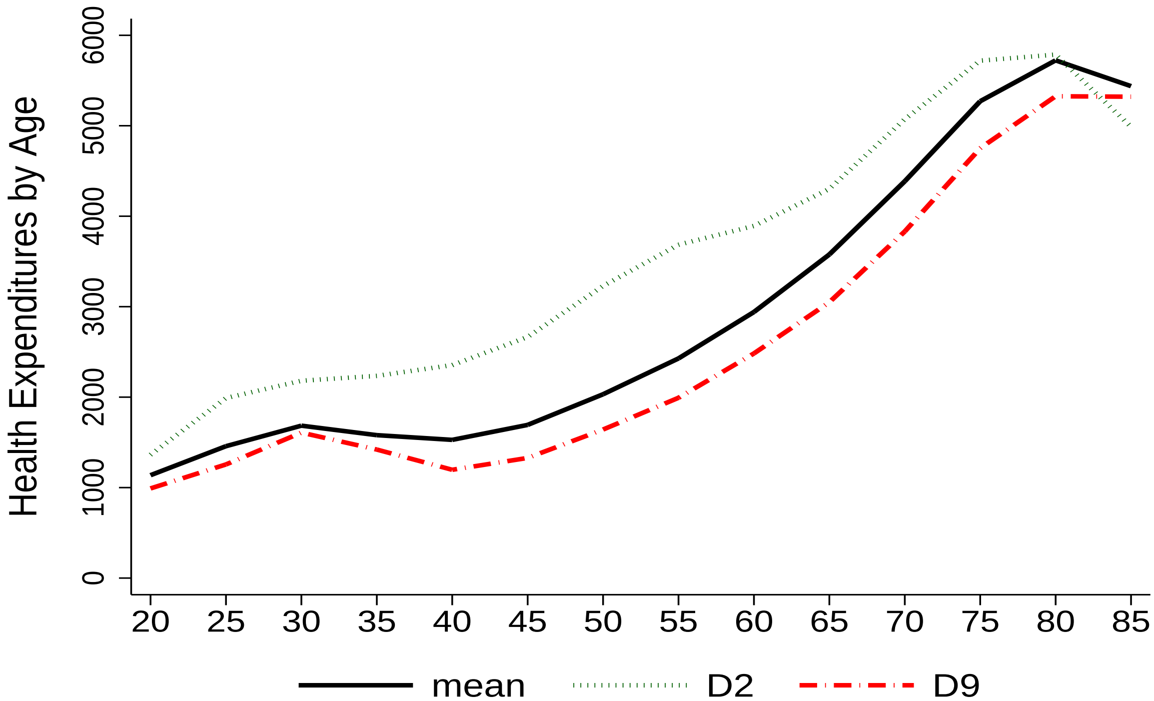

Figure 1: Health Expenditures in the Netherlands by Income Group, 2014

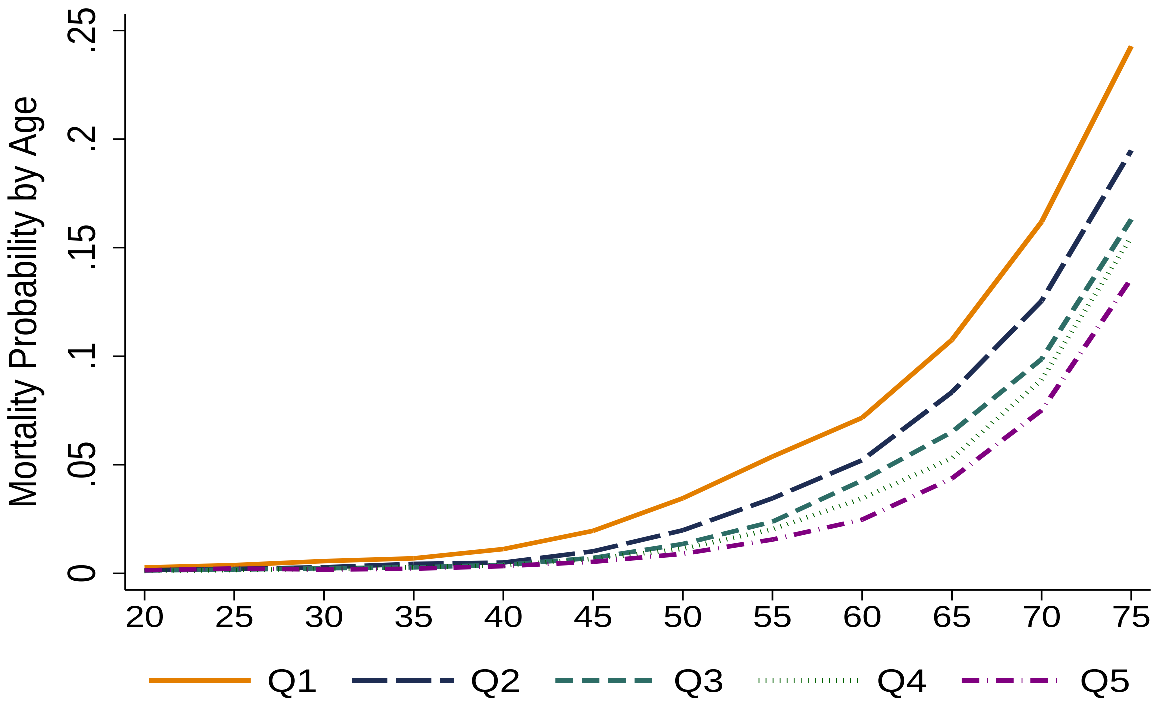

Figure 2: Mortality Probabilities in the Netherlands by Income Group, 2011-2014

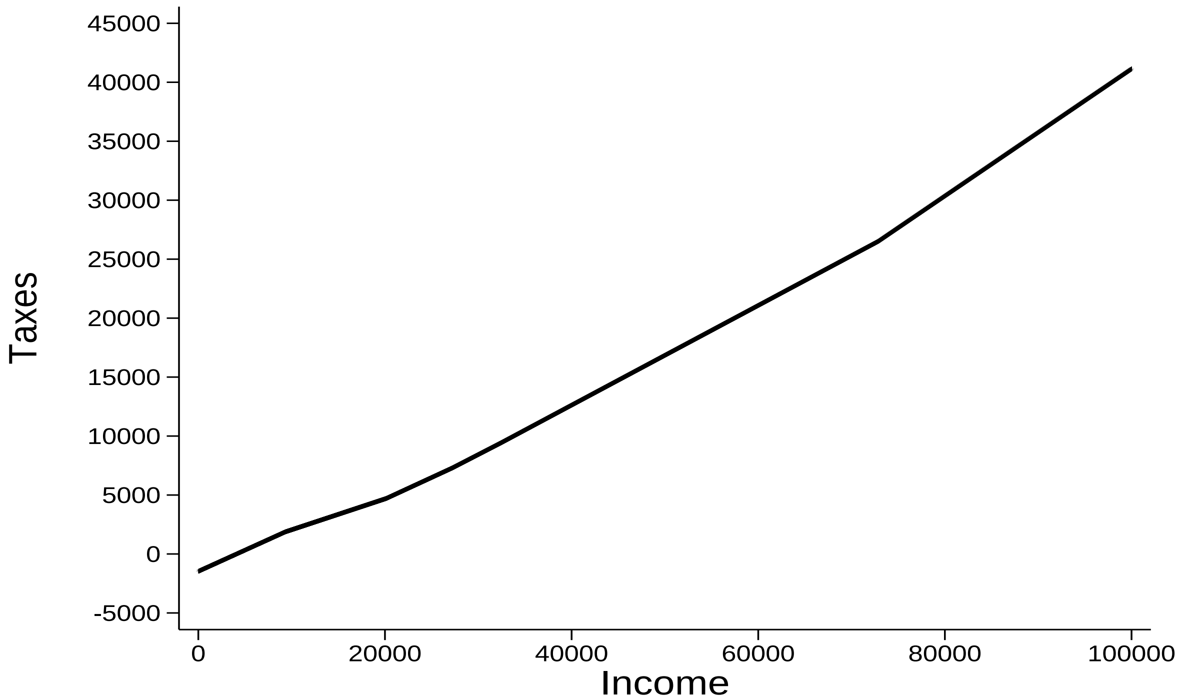

Figure 3: Income tax schedule faced by a working age couple without children.

Table 1: Marginal Income Tax Rates (in %), 2017

Lower (€)	Upper (€)	Working Age	Retirement Age
		on Labor Earnings	
	19,982	36.55	18.65
19,983	33,791	40.80	22.90
33,792	67,072	40.80	40.80
67,073		52.00	52.00
		on Significant Share Holdings	
		25.00	25.00
		on Asset Holdings	
	50,000	0.00	0.00
50,000		30.00	30.00

Source: *de Belastingdienst*, National Tax Office.

Table 2: Tax Credit Schedules, 2017

Lower (€)	Upper (€)	Working Age	Retirement Age
		General Tax Credit	
	19,982	2,254	1,151
19,983	67,068	$2,254 - 4.784\% \times (y - 19,982)$	$1,151 - 2.443\% \times (y - 19,982)$
		Earned Income Tax Credit	
0	9,309	$1.772\% \times y_l$	$0.904\% \times y_l$
9,310	20,108	$165 + 28.371\% \times (y_l - 9,339)$	$86 + 14.449\% \times (y_l - 9,339)$
20,109	32,444	3,233	1,645
32,445	121,972	$3,233 - 3.6\% \times (y_l - 32,444)$	$1,645 - 1.837\% \times (y_l - 32,444)$
121,973		0	0
		Child Tax Credit	
0	4,895	0	0
4,896	33,065	$1,043 + 6.159\% \times (y_l - 4,895)$	$533 + 3.143\% \times (y_l - 4,895)$
33,066		2,778	1,418
		Old Age Tax Credit	
	36,057		1,292
36,058			71

Note: y_l is labor income, and y is taxable income.
Source: *de Belastingdienst*, National Tax Office.

Table 3: National Income and Product Accounts, 2000–2010
(Values Divided by Adjusted GDP)

Total Income	1.000
Labor Income	0.595
Compensation of employees	0.529
70% of proprietors' income	0.067
Capital Income	0.405
Profits	0.164
30% of proprietors' income	0.029
Indirect business taxes	0.110
Less: Sales tax	0.108
Consumption of fixed capital	0.174
Imputed capital services	0.037
Consumer durable services	0.013
Government capital services	0.024
Total Product	1.000
Consumption	0.707
Government	0.231
Investment	0.214
Private	0.174
Government	0.039
Net Exports	0.078

Source: Dutch Bureau of Statistics

Table 4: Fixed Asset Table, 2005–2014
(Values Divided by Adjusted GDP)

Total Stock	5.261
Fixed Assets	3.014
Private	2.453
Public	0.561
Consumer durables	0.295
Land	1.871
Inventories	0.139
Oil and gas	0.237

Source: Dutch Bureau of Statistics

Table 5: Flow of Funds, 2005–2014
(Values Divided by Adjusted GDP)

Household Net Worth	3.895
Assets	5.130
Tangible	2.466
Financial	2.664
Liabilities	1.236
Government Debt	0.613
Federal Government	0.556

Source: Dutch Bureau of Statistics

Table 6: Population, Employment, and Hours, 2000-2010

Population in Millions	
All ages	16.26
Ages 16 to 64	10.78
Population Growth (%)	
All ages	0.45
Ages 16 to 64	0.33
Annual hours per worker	1,432
Annual hours per person	1,135

Source: Dutch Bureau of Statistics

Table 7: Overview of Quantitative Results

	Equilibrium					Constrained Efficient				
	Expenditures		Labor Market			Expenditures		Labor Market		
Type	Consumption	Health	Earnings	Hours	Mortality	Consumption	Health	Earnings	Hours	Mortality
0	0.225	0.038	0.219	0.219	0.233	0.315	0.061	0.361	0.361	0.226
HN	0.262	0.048	0.592	0.395	0.231	0.389	0.081	0.725	0.483	0.222
HI	0.177	0.032	0.369	0.246	0.237	0.252	0.049	0.411	0.274	0.230
LN	0.177	0.032	0.369	0.369	0.237	0.252	0.049	0.411	0.411	0.230
LI	0.121	0.021	0.224	0.224	0.244	0.164	0.028	0.184	0.184	0.238
HNN	0.240	0.021				0.389	0.034			
HIN	0.162	0.014				0.252	0.022			
LNN	0.162	0.014				0.252	0.022			
LIN	0.111	0.010				0.164	0.014			
HNI	0.240	0.021				0.389	0.034			
HII	0.162	0.014				0.252	0.022			
LNI	0.162	0.014				0.252	0.022			
LII	0.111	0.010				0.164	0.014			

Note: H is high, L is low, N is non-injured, and I is injured, and these indices are in chronological order.

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