IMES DISCUSSION PAPER SERIES

Sustainability of Social Security in the Aging Economy from the Perspective of Improving Health

Tomoaki Kotera

Discussion Paper No. 2020-E-12

IMES

INSTITUTE FOR MONETARY AND ECONOMIC STUDIES

BANK OF JAPAN

2-1-1 NIHONBASHI-HONGOKUCHO
CHUO-KU, TOKYO 103-8660
JAPAN

IMES Discussion Paper Series 2020-E-12
August 2020

Sustainability of Social Security in the Aging Economy from the Perspective of Improving Health

Tomoaki Kotera*

Abstract

An aging economy is widely believed to increase the recipients of Social Security and thus increase the fiscal burden. However, since the health condition of the elderly today is better than before and may continue to improve in the future, the number of elderly workers may increase. This paper studies the quantitative role of old workers in the sustainability of Social Security in an aging economy by developing a computable overlapping generations model with heterogeneous agents in a general equilibrium framework. The distinctive feature of the model is the incorporation of health status linked to survival probability, medical expenditures, and disutility of labor. The model simulation shows that old workers play a significant role in mitigating the fiscal cost and the effect remains pronounced when Social Security reform is implemented. It also highlights the crucial role of the projected future health status of the population in quantifying the fiscal cost.

Keywords: Elderly Workers; Health; Social Security Reform; Benefit Claim; Overlapping Generations

JEL classification: H55, I13, J22

* Economist, Institute for Monetary and Economic Studies, Bank of Japan (currently, Assistant Professor, Graduate School of Economics and Management, Tohoku University, E-mail: tomoaki.kotera.b1@tohoku.ac.jp)

The author is grateful for discussions with Toni Braun, Daisuke Ikeda, Yuto Iwasaki, Makoto Nakajima, Shigenori Shiratsuka, Nao Sudo, and Tomoaki Yamada. The author thanks to participants in the 5th Annual CIGS End of Year Macroeconomics Conference, GRIPS Workshop on Policies in Macroeconomics, 2019 JEA Spring Meetings, and SWET 2019 for helpful comments. The views expressed in this paper are those of the author and do not necessarily reflect the official views of the Bank of Japan.

1. Introduction

Population aging has advanced in developed countries, and the United States is not an exception. In 1960, the old-age dependency ratio – the ratio of individuals aged 65 and older to those aged 25 to 64 – was only 19.4%. But, the ratio has increased, reaching 24.7% in 2010, and the United Nations projects that it will hit 45.3% in 2050.[1] An imminent issue from this aging economy is the sustainability of the Social Security system: the largest social insurance program for old individuals.[2][3] Currently, there are increasing concerns over how much tax the government has to impose to sustain Social Security.

The main argument of this paper is that current and future elderlies are not the same as elderlies in the past. In my paper, I define elderlies as those aged 70 and older. Evidence suggests that elderlies have become healthier in the last 35 years. Concurrently, the fraction of elderly workers has gradually increased. In 2015, the employment rate for males aged 70 to 80 was 18.5%. Thus, old workers can be a silver lining for the sustainability of Social Security. Interestingly, the Bureau of Labor Statistics reports that the number of old workers is expected to rise in future because of further improving health (Toossi and Torpey (2017)).[4] Therefore, the contribution of old workers to the sustainability of Social Security will likely become larger as the economy ages.

Against this background, this paper addresses two specific questions. First, if old individuals live more healthy, what will the elderlies' work decisions be in an aging economy? Will they stay in the labor market and work longer than previous generations as they age? Second, what will be the impact of these old workers' decisions on the sustainability of the Social Security system? Will it mitigate the fiscal cost to sustain Social Security significantly? To the best of my knowledge, this is the first paper to address this issue from the perspective of improving health.

I develop a computable overlapping generations model with heterogeneous agents in a general equilibrium framework, which features a distinct role for health status, especially for old individuals. The model, calibrated to the United States economy of 2010, successfully replicates employment rates over the life cy-

[1]The data source is the United Nations, World Population Projects-2017 Revision. This project is based on the medium-variant population projections.

[2]Other dimensions regarding aging are entrepreneurship (Liang et al. (2018); Engbom (2019)) and monetary policy (Wong (2019)).

[3]As of 2013, Social Security spends 4.1% of GDP. According to the projection of "The 2014 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds", this ratio will increase to 4.9% in 2036.

[4]Another dimension, Toossi and Torpey (2017) point out, is the larger fraction of college graduates because they tend to work longer than high-school graduates. My paper does not take into consideration this aspect.

cle, especially for individuals aged 70-80. The model is then used to simulate the aging economy of 2050 to evaluate the impact of old workers on the sustainability of Social Security. The simulation results show that a larger fraction of old individuals continues to work because of improving health status and the increase in the employment rate reduces the fiscal burden significantly. The role of old workers remains stark if it accompanies Social Security reform. It is the incorporation of improving health status in the model that generates these large impacts. Conversely, the impacts would be diminished if improving health status were not taken into account.

The role of health status in the model is as follows. Health status is assumed to have a linkage with disutility of labor and medical expenditures. Specifically, if health status is worse, disutility of labor and medical expenditures are higher. In addition, health status is assumed to be closely related to individuals' survival probabilities. By using this relationship, a change in health status in the future can be calibrated by exploiting the projected survival probability in the aging economy. This rich description of health status and its relationships with disutility of labor, medical expenditures, and survival probability affect individuals' labor supply decisions significantly.

The model economy has three agents: individuals, firms, and a government. In each period, new individuals enter the economy and die according to survival probabilities. In the beginning of the period, individuals' health status depreciates, and an idiosyncratic labor productivity shock and a taste shock for disutility of labor arrive. Subsequently, individuals make a working decision. They have three choices: full-time, part-time, and no work. Under the Social Security rules, they can collect Social Security benefits at the normal retirement age, but they can also claim earlier or later. They can decide whether to work every period, so that they can work even though they receive benefits. Again, this assumption underlies the Social Security rules. When working, individuals obtain labor earnings and employer-provided health insurance if they are under age 65. Next, a medical shock hits, and individuals incur medical expenditures. After this event, individuals are provided Medicare, Social Security and/or a transfer from the government, depending on eligibility. The government imposes taxes and issues debt to finance these expenditures. Lastly, individuals make a decision on consumption and asset holdings for the next period. Firms combine capital and labor according to a constant-returns-to-scale production technology.

The model is solved for the stationary equilibrium and then carefully calibrated to the United States economy of 2010. Specifically, the population growth rate is set to match the old-age dependency ratio, which is a key variable in the aging economy. In addition, parameters for health status deprecation and medical shocks are calibrated to fit the data on survival probability and the distribution of medical expenditures, respectively. The calibrated model is then used to simulate the aging economy of 2050 by changing the aforementioned two variables. Relative to the 2010 economy, the population growth rate falls and health status depreciation drops in the 2050 economy. I then examine how many old workers there will be and how much tax the government will have to impose to sustain the Social Security system.

The simulation results indicate that the fraction of old workers rises remarkably in the aging economy. In particular, relative to the 2010 economy, the employment rate for all workers aged 70-80 becomes 2.06 times as high as the original level in 2010. Because of improving health status (i.e., lower values of health status depreciation), the disutility of labor falls, which incentivizes old individuals to work longer. That said, the government still has to impose an additional tax to balance the budget. This fiscal cost is attributable to fewer young workers driven by the decrease in the population growth rate. However, the role of old workers should not be masked by the additional tax: if old workers were forced to stop working and instead received Social Security benefits, this fiscal burden would be even heavier. The importance of old workers is still pronounced in the case of Social Security reform, where the normal retirement age is raised by 4 years, as discussed in practice. Regardless of the presence of old workers, individuals accumulate more assets and work longer because they receive less Social Security benefits in total. As a result of these changes in individuals' incentives to work, the fiscal cost becomes smaller, and social welfare rises. Even in this case, however, old workers play an important role in reducing the fiscal burden.

In these simulation results, it is worth emphasizing the role of health status. To isolate its role, if the level of health status is kept constant at its level in the 2010 economy, the presence of old workers becomes inconsequential. Since the number of old workers rises very modestly, the impact of old workers becomes smaller. Furthermore, even if the Social Security system is reformed, old workers will not play a significant role in reducing the fiscal cost. Hence, taking into account future health status improvements is crucial for understanding the relationship between old workers and the sustainability of the Social Security system in an aging economy.

This paper contributes to the literature on the sustainability of Social Security with population aging in a computable overlapping generations model. De Nardi et al. (1999), Kotlikoff et al. (2007), Díaz-Gimene and Díaz-Saavedra (2009), İmrohoroğlu and Kitao (2012), and Kitao (2014) employ a computable overlapping generations model to evaluate how to sustain the Social Security system in an aging economy.[5]

[5] Auerbach and Kotlikoff (1987) is the first paper to develop this type of large-scale overlapping generations model. Many

However, the literature does not focus on the labor supply decisions of elderlies. All four of the papers above abstract from i) incorporating health status[6] and/or ii) allowing old individuals to work.[7] This paper carefully characterizes elderlies' working decisions by taking into account health status and the possibility to work even after receiving Social Security benefits.

The rest of the paper is structured as follows. Section 2 summarizes the evidence on old workers and health status. The model is presented in Section 3. In Section 4, the model is calibrated to the United States economy of 2010. In Section 5, the model is simulated for the economy of 2050 and the main results of this paper are presented. Section 6 concludes.

2. Evidence on Old Workers and Health Status

This section briefly documents upward trends in the employment rate for elderlies and health status in the United States. The sample is restricted to males. I make a comment on this restriction in Section 4.

2.1 Old Workers

I calculate the employment rate for males between ages 70 and 80 for 30 years. The data source is the Integrated Public Use Microdata Series (IPUMS). As presented in Figure 1, the employment rate for elderly males has increased gradually. In 1985, the employment rate for these individuals was 13.7%. However, this fraction reached 18.5% in 2015.

2.2 Health Status

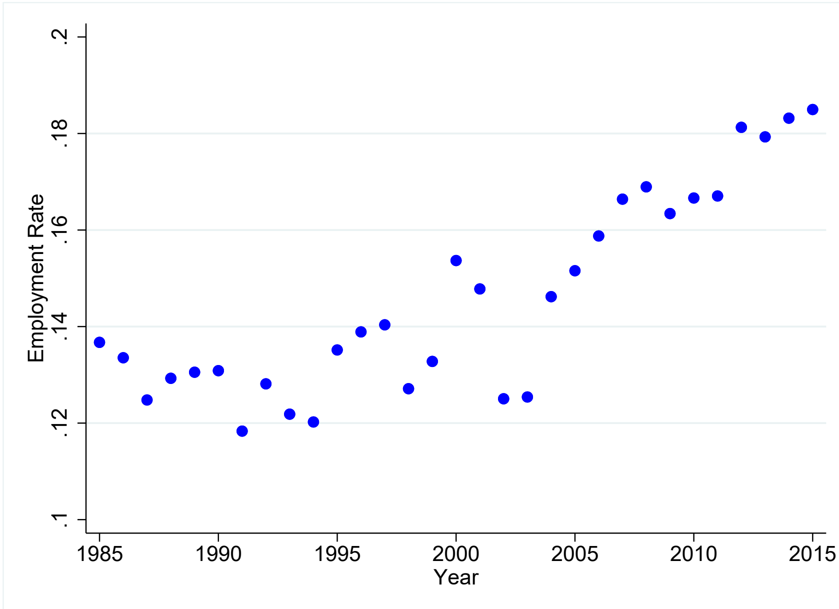
Surprisingly, the cause of the gradual increase in elderly workers is unclear. My paper argues that improving health status is potentially the main driving force. Figure 2 plots the mortality rates between ages 70 and 80 in 1985 and 2015, according to the Human Mortality Database. As can be seen, the mortality rate declines

papers employ a richer version of Auerbach and Kotlikoff (1987) to address the issue of Social Security reform (Conesa and Kruger (1999); Kotlikoff et al. (1999); Nishiyama and Smetters (2007); İmrohoroğlu and Kitao (2009)).

[6] İmrohoroğlu and Kitao (2012) is the only paper to incorporate health status into their model, but they assume two health statuses: good and bad. Individuals change their health status every period depending upon the age-specific transition probability. Health status is independent of survival probability, which makes it difficult to embed improving health into the model.

[7] De Nardi et al. (1999), Kotlikoff et al. (2007), and İmrohoroğlu and Kitao (2012) assume that individuals must retire from the labor market at the age of 65, 55, and 70, respectively.

Figure 1: Employment Rate for Males at Age 70-80 over 30 Years



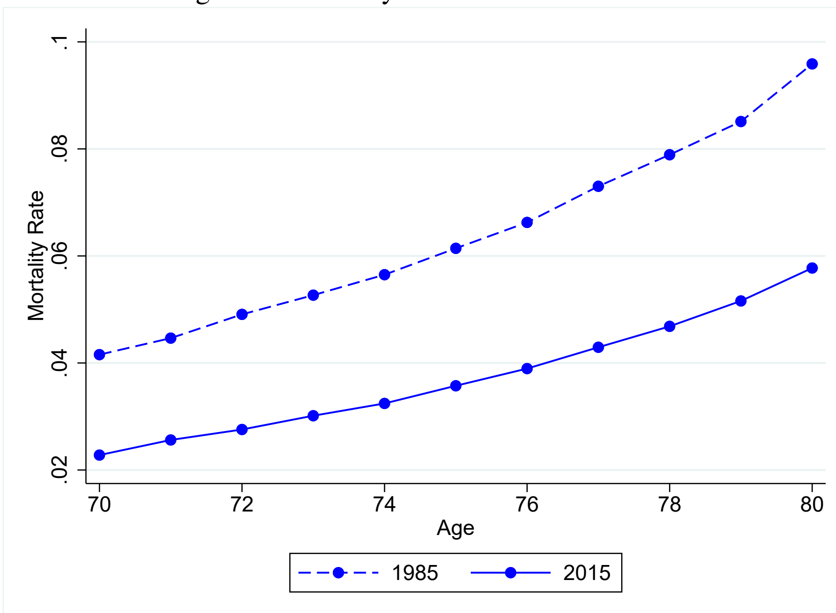
Notes: Data source is the Integrated Public Use Microdata Series.

more significantly from 1985 to 2015. The average decrease in the rate is 2.66%, which is more than twice as high as between 1955 and 1985 (1.18%). Furthermore, this decline becomes starker as males grow older. For those aged 80, the mortality rate dropped by 3.81%. To be clear about how large this decline is, I calculate the age in 1985 when the mortality rates for a particular age occurs in 2015.[8] I call this the mortality-equivalent age and present the result in Figure 3. This figure indicates that the morality-equivalent age of 2015 is much younger than the actual age. On average, this gap is 6.43 years. This number is striking compared to the difference between 1985 and 1955(2.25 years), suggesting that elderly males have become much healthier in the last 30 years.[9] Since the mortality rates are projected to continue declining in the future, according to Bell and Miller (2005), improving health status might potentially continue, which would induce a larger fraction of elderlies to work. The goal of this paper is to project the number of elderly workers in the future, and explore how important they are in regard to the sustainability of the Social Security system.

[8]Following Milligan and Wise (2015), I interpolate linearly if the mortality rate at a certain age in 2015 is between ages in 1980.

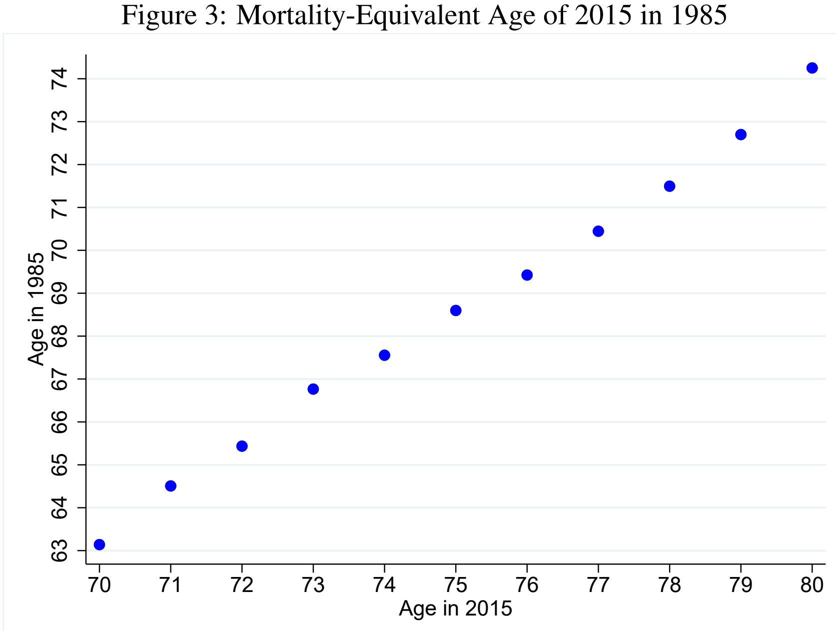
[9]Elderly females are healthier as well, but the magnitude of the difference between 1985 and 2015 is as large as the difference between 1955 and 1985. The gap between the morality-equivalent age and the actual age is 3.40 years (1985-2015) and 4.21 years (1955-1985), respectively.

Figure 2: Mortality Rates in 1985 and 2015



Notes: Data source is the Human Mortality Database

Figure 3: Mortality-Equivalent Age of 2015 in 1985



Notes: The mortality-equivalent age is defined as the age when mortality rates in a particular age in 2015 occur in 1985. Data source is the Human Mortality Database

3. Model

The model builds on a quantitative overlapping generations model, modified to incorporate health status in a unique way. There are individuals, firms, and the government. The health status of individuals changes as they get older. The level of health status affects individuals' survival probabilities, medical expenditures, and disutility of labor. Thus, health status affects individuals' consumption, saving, labor supply decisions, and eventually the sustainability of the Social Security system. The model aims to quantify the impact of improving health status and increasing old workers. In the following sections, the model environment is described, which is followed by a description of each agent in the economy.

3.1 Model Environment

3.1.1 Demographics

The economy is populated by overlapping generations of individuals of age $j = 1, 2, \cdots, J$. Each individual faces mortality risk. Specifically, individuals of age j survive to the next age of $j+1$ with probability Φ_j. This survival probability depends on the health status of individuals, which will be described shortly. The size of the new cohort grows at a constant rate n. Let μ denote the population distribution.

3.1.2 Health Status

The health status of individuals of age j, h_j, changes as they get older and is given by

$$h_j = h_{j-1} - \kappa_j, \tag{1}$$

where κ_j captures the age-specific health status depreciation, which is assumed to be identical across individuals of age j. Thus, health status has no heterogeneity within a cohort.

As mentioned above, individuals' health status affects three key ingredients. First, health status affects medical expenses. Individuals face a medical shock ξ, which is i.i.d. across individuals. Upon occurrence of the shock, the individual has to pay medical expense $m_j(\xi)$, which is given by the distance between initial health and current health status.

$$m_j(\xi) = A^m \left(h_0 - (h_j - \xi)\right)^\gamma, \tag{2}$$

where A^m is a coefficient term and γ is a parameter that governs the elasticity of medical expenses with respect to the change in health status. The interpretation of the health status shock ξ is a deterioration of health status from the current level of h_j. But an underlying assumption is that health status recovers completely to the original level of h_j by consuming medical services, which requires medical expense $m_j(\xi)$. This assumption allows the model to keep a homogenous health level within a cohort and thus enables the model to match the data on survival probability and medical expenditures jointly as will be explained in the next section.

Second, health status affects individuals' disutility of labor, which will be specified below. Third, health status determines survival probabilities facing individuals. Specifically, following Scholz and Seshadri (2013) and Ozkan (2017), the survival probability facing an individual of age j depends solely on current health status h_j: $\Phi_j = \Phi(h_j)$. The survival probability is exogenously given. In practice, health status could affect other key components such as labor productivity.[10] But, since a relationship between this type of health status and labor productivity is hard to observe in the data, such a relationship is not considered in the model.

3.2 Individuals

Individuals' labor earnings e are given by the following equation:

$$e = w\eta_j \varepsilon l, \tag{3}$$

where w represents the market wage, η_j is the age-specific labor productivity, ε is an idiosyncratic labor productivity shock that follows a Markov process, and l is hours of work. There are three choices of l: $l \in \{0, \bar{l}_p, \bar{l}_f\}$, where $\bar{l}_p$ and $\bar{l}_f$ are working hours for part-time and full-time jobs. I fix three working hours because they are concentrated on specific hours in the data. Furthermore, both $\bar{l}_p$ and $\bar{l}_f$ are constant over the life cycle. This assumption is consistent with the data.

Following İmrohoroğlu and Kitao (2012), my model incorporates the decision to claim Social Security or not. Normally, individuals aged j_R and older are eligible for Social Security ss. However, they can claim Social Security benefits earlier or later. Let j_{R_0} denote the initial age when they can claim. This assumption

[10] See French (2005), Capatina (2015), and De Nardi et al. (2018).

is reflected by the current Social Security system. The Social Security system is a pay-as-you-go pension system. The amount of Social Security benefits is calculated by using individuals' average lifetime earnings $\overline{e}$. Depending upon when they are claimed, Social Security benefits are adjusted downward or upward. I present an explanation of the Social Security system and calculation of Social Security benefits in the next section. Because they are allowed to work even though they collect Social Security benefits, individuals can decide whether to work each period or not.

The initial assets is 0 for every individual. Thereafter, they can accumulate assets with market interest rate r. Their lifetime utility is given by

$$\mathbb{E}\left[\sum_{j=1}^{J}\beta^{j-1}\left(\prod_{k=1}^{j}\Phi(h_k)\right)\left(u\left(c,h_j,l,\theta\right)\right)\right],$$

where c represents consumption and θ denotes disutility of labor. An important assumption is that θ is an i.i.d. random variable. This is a similar setting to Fan et al. (2018). I specify the utility function in the next section.

Individuals are heterogeneous in the following dimensions: age group j, assets a, health status h_j, average lifetime earnings $\overline{e}$, idiosyncratic labor productivity shock ε, taste shock θ, and medical shock ξ. Let $\mathbf{x} = \left(j,a,h_j,\overline{e},\varepsilon,\theta\right)$. In each period, they make optimal choices of $\{c,a',l\}$ and the decision to claim or not d after the age of j_{R_0}.

When individuals die, they derive "warm-glow" utility $b\left(a'\right)$ from leaving bequests. These bequests are collected by the government and distributed as a lump-sum transfer tr^*. Hence, the following equation is satisfied:

$$tr^* = \sum_{\mathbf{x}}\left(1-\Phi(h_j)\right)a'\left(\mathbf{x}\right)\mu\left(\mathbf{x}\right). \tag{4}$$

3.3 Government

The government provides Social Security benefits and the government medical insurance program, Medicare. Medicare is provided to those aged 65 or older and it covers a fraction q^{MCR} of medical expense $m_j(\xi)$. For those under age 65, who are not eligible for Medicare, individuals are offered health insurance from employers. Specifically, firms provide their employees with health insurance that covers a fraction

q^{EMP} of medical expense $m_j(\xi)$.

In addition to these benefits, as in the literature (e.g., Pashchenko and Porapakkarm (2013); Kopecky and Koreshkova (2014); De Nardi et al. (2016); Conesa et al. (2018)), the government provides a lump-sum transfer benefit tr to individuals who satisfy either of the following two criteria: i) after-tax total income plus assets is below the minimum consumption level, denoted by $c_{\min}$, or ii) after-tax total income plus assets net of out-of-pocket medical expenditure is below $c_{\min}$. In addition, the government consumes G and pays interest rate r on the government debt D.

To finance these expenditures, the government imposes various taxes. Such taxes consist of the Social Security tax τ^{ss}, the Medicare tax τ^{MCR}, the consumption tax τ^{c}, and a progressive tax on total income τ^{I}. The Social Security tax and the Medicare tax are imposed on labor earnings. For Social Security, no additional tax is imposed if labor earnings are above a maximum amount, denoted by e^{ss}. The total income on which the progressive tax is imposed is defined as the sum of capital income ra, and labor earning e. I adopt a standard tax schedule, developed by Gouveia and Strauss (1994), to pin down the tax rate on income:

$$\tau^{I}\left[ra+e\right] \;=\; \lambda_0\left\{(ra+e)-\left((ra+e)^{-\lambda_1}+\lambda_2\right)^{\frac{-1}{\lambda_1}}\right\},$$

where $\{\lambda_0,\lambda_1,\lambda_2\}$ are parameters.

To summarize, the government flow budget constraint is given by

$$G+(1+r)D+\left[\sum_{\mathbf{x}} ss(\mathbf{x})+\sum_{\mathbf{x}} tr(\mathbf{x})+q^{EMR}\sum_{\mathbf{x}} m(\mathbf{x})\right]\mu(\mathbf{x})=$$
$$\sum_{\mathbf{x}}\left[\tau^{I}\left[e(\mathbf{x})+ra(\mathbf{x})\right](e(\mathbf{x})+ra(\mathbf{x}))+\tau^{ss}\min\{e(\mathbf{x}),e^{ss}\}+\tau^{MCR}e(\mathbf{x})+\tau^{c}c(\mathbf{x})\right]\mu(\mathbf{x})+D'. \quad (5)$$

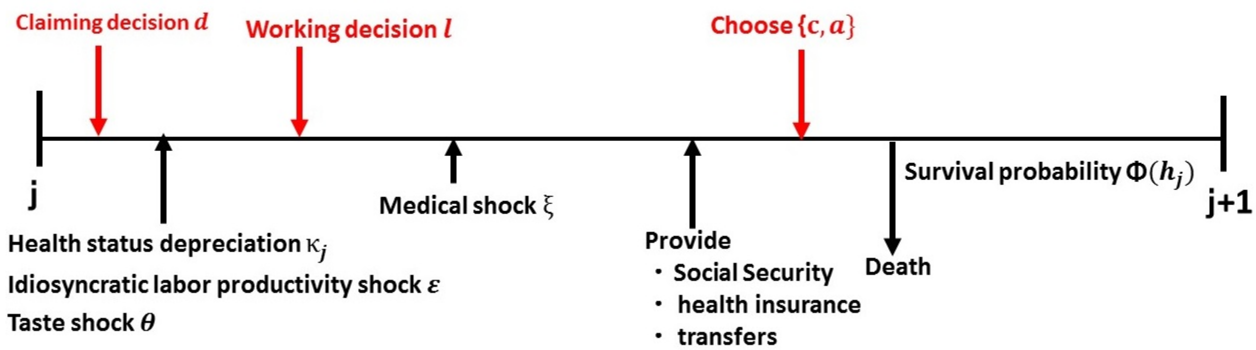
3.4 Firms

Firms produce a homogenous good. The aggregate production function exhibits constant returns to scale:

$$Y=AF(K,L)=AK^{\alpha}L^{1-\alpha},$$

where A is aggregate productivity, K denotes aggregate capital, and L is aggregate labor. Aggregate capital is depreciated by δ.

Figure 4: Model Timing



Taking the first-order conditions yields

$$A\alpha K^{\alpha-1}L^{1-\alpha}-(r+\delta)=0, \tag{6}$$

$$A(1-\alpha)K^{\alpha}L^{-\alpha}-w=0. \tag{7}$$

An employer-provided health insurance premium p^{EMP} is determined by the zero profit condition:

$$p^{EMP}\sum_{\mathbf{1_{l\neq 0}},j<41}\mu(\mathbf{x})=q^{EMP}\sum_{\mathbf{1_{l\neq 0}},j<41}m(\mathbf{x})\mu(\mathbf{x}). \tag{8}$$

3.5 Individuals' Decision Problem

Figure 4 illustrates the timing of events. If they are eligible for Social Security, individuals can initially make claiming decision d. Then, health status depreciates by κ_j, and idiosyncratic labor productivity shock ε and taste shock for disutility from working θ arrive. Subsequently, individuals make the decision on working l. After this decision, medical shock ξ hits and Social Security, Medicare and the government transfer are provided if they are eligible. Lastly, individuals choose consumption, and assets. Depending on survival probabilities, they then move on to the next period.

I formulate individuals' problem recursively. The value function $V(\mathbf{x})$ is written as

$$V(\mathbf{x})=\max_{\{c,a',l,d\}}\mathbb{E}\left[u(c,h_j,l,\theta)+\beta\left[\Phi(h_j)\mathbb{E}\left[V\left(\mathbf{x}'\right)\right]+(1-\Phi(h_j))\,b\left(a'\right)\right]\right],$$

subject to

$$(1+\tau^{c})\,c+a'+oop+\mathbf{1}_{l\neq 0}\mathbf{1}_{j<41}p^{EMP}=a+\tilde{y}+tr+tr^{*},$$

$$oop=\left(1-\mathbf{1}_{l\neq 0}\mathbf{1}_{j<41}q^{EMP}-\mathbf{1}_{j\geq 41}q^{MCR}\right)m,$$

$$\tilde{y}=\left(1-\tau^{I}\left[e+ra\right]\right)(e+ra)+ss-\tau^{ss}\min\left\{e,e^{ss}\right\}-\tau^{MCR}e,$$

$$tr=\max\left\{0,\left(\left(1+\tau^{c}\right)c_{\min}-\left(\tilde{y}+a-oop\right)\right)\right\},$$

$$a'\geq 0. \tag{9}$$

As (9) indicates, individuals are not allowed to borrow against future income. This constraint excludes the case where individuals die with debt.

3.6 Stationary Equilibrium

In this section, I define the stationary equilibrium and set of conditions that are satisfied in the model.

Definition: For a given set of population growth n and government policy variables $\{G,D,ss,\tau^{ss},e^{ss},tr,q^{MCR},\tau^{c},\tau^{I},\tau^{MCR}\}$, a stationary equilibrium consists of individuals' decision rules $\{c,a',l\}$ for each state, factor prices, an employer-provided health insurance premium p^{EMP}, a lump-sum bequest transfer tr^{*}, and the distribution of individuals $\mu(\mathbf{x})$ that satisfy the following conditions:

- Individuals' allocation rule solves the recursive optimization problem defined in Section 3.5.
- Factor prices are determined by (6) and (7).
- The employer-provided health insurance premium p^{EMP} is pinned down by the insurance company's non-profit condition (8).
- The labor and capital market clearing conditions are as follows.

$$L=\sum_{\mathbf{x}}\eta_{j}\varepsilon l(\mathbf{x})\mu(\mathbf{x}). \tag{10}$$

$$K=\sum_{\mathbf{x}}a(\mathbf{x})\mu(\mathbf{x})-D. \tag{11}$$

- The equation for the lump-sum bequest transfer (4) holds.
- The government budget constraint (5) holds.
- The distribution of individuals across states $\mu(\mathbf{x})$ is stationary. That is, $\mu = T_\mu \mu$, where T_μ is a one-period recursive operator on the distribution.

4. Calibration and Model Performance

This section lays out the calibration strategy and examines whether the calibrated model replicates employment rates especially for old workers, which is the major focus of this paper. The model economy is assumed to be in a stationary equilibrium and the model is calibrated to the United States economy of 2010. Specifically, individuals in the model are calibrated to the males data only. There are two reasons for this choice. First, the employment rates for females have risen significantly in the United States and the model abstracts from underlying driving forces. Second, the gap of the employment rates between males and females has shrunk significantly, so that the model considered in this paper can be regarded as an economy in which the gap has vanished.[11] For these reasons, focusing on males in the calibration allows us to derive sharp quantitative implications of old workers for the sustainability of Social Security.

4.1 Calibration

4.1.1 Demographics

Each j corresponds to 1 year. Individuals enter the economy at age 25 and the maximum age is set at 109, so that $J = 85$. The growth rate of newly-born individuals is set at n =0.017 to match the old-age dependency ratio of 24.7% in 2010.

[11] According to OECD statistics, the gap in labor force participation rates at age 15-64 between males and females was 25.9% in 1980. However, this gap had fallen to 11.2% by 2010.

4.1.2 Preferences and technologies

The subjective discount factor for individuals' utility is set at $\beta = 0.96$. Individuals' utility function takes the following form:

$$u(c,h_j,l,\theta) \quad = \quad \begin{cases} \frac{(c)^{1-\sigma}}{1-\sigma} & (l=0\text{: no work}) \\ \frac{(c)^{1-\sigma}}{1-\sigma} - \theta\psi h_j^{\zeta} & (l=\bar{l}_p\text{: part-time}) \\ \frac{(c)^{1-\sigma}}{1-\sigma} - \theta h_j^{\zeta} & (l=\bar{l}_f\text{: full-time}). \end{cases}$$

The inverse of the intertemporal elasticity of substitution is set at $\sigma = 3$, which is standard in the literature. The values of working hours, $\bar{l}_f$ and $\bar{l}_p$, are set at 0.33 and 0.17, respectively, to reflect working hours for the majority of full-time and part-time workers, i.e. 40 and 20 hours, respectively, according to the IPUMS. Parameter ζ governs the elasticity of disutility of labor with respect to health status of workers, and ψ is the relative weight of disutility of labor for part-time workers. An idiosyncratic shock to disutility of labor is introduced to reflect the stark gap of leisure time across individuals as documented by Aguiar and Hurst (2007). The shock is assumed to follow a log-normal distribution:

$$\log(\theta) \sim \mathcal{N}\left(\mu_\theta, \sigma_\theta^2\right).$$

The remaining parameters $\{\zeta, \psi, \mu_\theta, \sigma_\theta^2\}$ are calibrated to match employment rates by age cohort and by the type of employment. Because there are only four free parameters, four target values are set: total employment rates at age 45 and 60; the employment rate at age 75; and the part-time employment rate at age 60. Although not perfect, the model successfully replicates these employment rates as shown in Table 2.

The utility from leaving bequest $b(a')$ takes the following form:

$$b\left(a'\right) = b_1 \frac{(b_2 + a')^{1-\sigma}}{1-\sigma},$$

where b_1 denotes the weight of the bequest motive and b_2 is a constant. This function is commonly employed in models incorporating bequest motives, including İmrohoroğlu and Kitao (2012). Parameter b_2 is set at $b_2 = \$444,000$ in 2004 United States dollars to reflect the amount of assets in the Health and Retirement

Study (HRS) for the period 1992-2006, estimated by French and Jones (2011). Parameter b_1 is set at $b_1 = \$5,505$, so that the ratio of the median value of net wealth at age 85 to the corresponding value at age 80 in the model is close to the value in the data.[12]

Regarding technologies, the capital income share parameter is set at $\alpha = 0.36$ and the capital depreciation rate is set at $\delta = 8.3\%$, so that the capital-output ratio becomes 2.5 and the investment-output ratio becomes 0.25. These target values for the given ratios are the same as in İmrohoroğlu and Kitao (2012). Finally, the technology level of the production function A is set so that the output becomes unity.

4.1.3 Labor earnings

Age-specific labor productivity η_j is set using the wage per hour by age from the IPUMS. The sample is restricted to males aged 65 and younger, because 66 has been the normal retirement age at which many individuals exit from the labor force. The definition of wage per hour is annual labor earnings (wage and salary income) divided by annual total working hours (calculated from hours per week and weeks worked).[13] The wage per hour η_j^{data} is then regressed on age variables as follows:

$$\eta_j^{data} = \alpha_0 + \alpha_1 j + \alpha_2 j^2. \tag{12}$$

The fitted wage per hour $\hat{\eta}_j^{data}$ from (12) is used for setting parameter $\eta_j = \hat{\eta}_j^{data}$. Figure 5 plots the data on wage per hour by age and its fitted curve. The labor productivity parameter η_j for age 66 and older is extrapolated using the fitted curve.

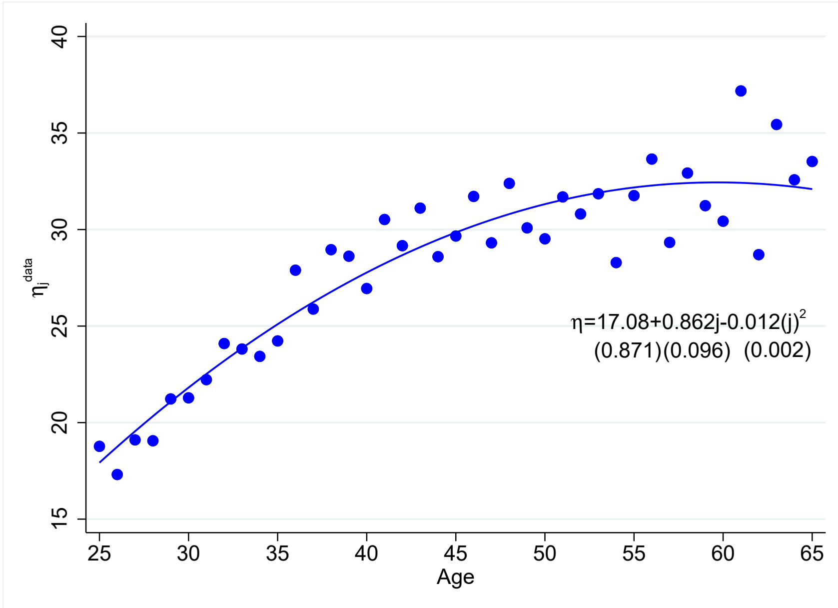
The idiosyncratic labor productivity shock ε is assumed to follow an AR(1) process in logs. Following Heathcote et al. (2010), the AR(1) coefficient is set at 0.97 and the variance of the white noise is set at 0.018.[14]

[12] The data source is the HRS. The definition of net wealth here is the sum of the value of housing, real estate, autos, liquid assets such as money accounts and savings accounts, individual retirement accounts, stocks, the value of farms or businesses, mutual funds, bonds and other assets, less mortgages and other debts. The net worth is divided into half for married couples. The net wealth for individuals aged 80 and 85 are given by the bins aged 78-82 and age 83-87, respectively.

[13] I deal with top-coded observations in the IPUMS by using the methodology of Heathcote et al. (2010).

[14] Heathcote et al. (2010) also focus on male hourly wages due to the selection problem in running an OLS regression to estimate the stochastic process of the shock.

Figure 5: η_j over the Life Cycle



Note: The dotted points indicate average male wage per hour from the data. Data source is the IPUMS. The dashed lines plot $\hat{\eta}_j$ by running a regression of (12).

4.1.4 Health status and insurance

The initial health status h_0 is normalized to unity. The survival probability function, which depends on health status, takes the following form:

$$\Phi(h_j) = \frac{1 - exp\left(-\phi_1 (h_j)^{\phi_2}\right)}{1 - exp\left(-\phi_1 (h_0)^{\phi_2}\right)}.$$

Parameters ϕ_1 and ϕ_2 are set at $\phi_1 = 0.0012$ and $\phi_2 = 1.53$, following Scholz and Seshadri (2013). Regarding health status depreciation κ_j, it is assumed that $\kappa_j = \bar{\kappa}^i$ for $i \in \{0, 1, ..., 12\}$. Specifically, $\kappa_j = \bar{\kappa}^0$ for $j \leq 20$ (age 45 or younger), $\kappa_j = \bar{\kappa}^i$ for $j = 20 + (i-1) \times 5$,...,$20 + i \times 5$,and $\kappa_j = \bar{\kappa}^{12}$ for $j \geq 75$ (age 100 or older). These $\bar{\kappa}^i$'s are set to match the survival probabilities for males from the life table of 2010, as reported in Bell and Miller (2005).

The medical shock ξ, which appears in the medical expense function (2), is assumed to follow a log-normal distribution:

$$\log(\xi) \sim \mathcal{N}\left(\mu_\xi, \sigma_\xi^2\right).$$

To capture the distribution of medical expenditures over the life cycle, the mean of the medical shock μ_ξ

Table 1: Calibration Result of the Parameters

Description	Parameter	Value
Health status depreciation (Age 44 and younger)	κ^1	0.0012
Health status depreciation (Ages 45 to 49)	κ^2	0.0032
Health status depreciation (Ages 50 to 54)	κ^3	0.0032
Health status depreciation (Ages 55 to 59)	κ^4	0.0057
Health status depreciation (Ages 60 to 64)	κ^5	0.0084
Health status depreciation (Ages 65 to 69)	κ^6	0.0128
Health status depreciation (Ages 70 to 74)	κ^7	0.0186
Health status depreciation (Ages 75 to 79)	κ^8	0.0247
Health status depreciation (Ages 80 to 84)	κ^9	0.0337
Health status depreciation (Ages 85 to 89)	κ^{10}	0.0379
Health status depreciation (Ages 90 to 94)	κ^{11}	0.0298
Health status depreciation (Ages 95 to 99)	κ^{12}	0.0134
Health status depreciation (Age 100 and older)	κ^{13}	0.0030
Mean value of log of medical shock (Age 39 and younger)	μ_{ξ_1}	-6.203
Mean value of log of medical shock (Ages 40 to 49)	μ_{ξ_2}	-5.400
Mean value of log of medical shock (Ages 50 to 59)	μ_{ξ_3}	-4.730
Mean value of log of medical shock (Ages 60 to 69)	μ_{ξ_4}	-4.350
Mean value of log of medical shock (Age 70 to older)	μ_{ξ_5}	-4.039
Standard deviation of log of medical shock	σ_ξ	5.809
Coefficient term for total medical expenses	A^m	0.125
Return to health status for total medical expenses	γ	0.850

is assumed to be age-dependent and can take five different values $\{\mu_{\xi_1}, \mu_{\xi_2}, \cdots, \mu_{\xi_5}\}$. The age cohort to which each mean value of the medical shock is applied is displayed in Table 1. The standard deviation is assumed to be constant over the life cycle. These parameter values along with A^m and γ in the medical expense function (2), are set so that the model replicates the moments of the medical expenses data reported in the Medical Expenditure Panel Survey (MEPS). The MEPS provides comprehensive data on health status, medical payments, and health insurance coverage. The age is capped at 85. For medical expenses, the total medical payments for males is used, which is given by the sum of out-of-pocket payments and medical costs covered by several types of health insurance coverage, including employer-provided health insurance and Medicare.[15] The data between 1996 and 2012 are used to obtain a sample size large enough for calculating moments. The average medical expenditures of the entire sample and the average of the upper one-third of the sample for different ages are used as the target moments. For details, see the Appendix A.

Table 1 reports the calibration results. As shown in Figure 6, with these calibrated parameter values the model fits the data well on the distribution of medical expenditures and survival probability by age.

Finally, the copayment rates q^{EMP} and q^{MCR} are calibrated to match the average ratio of medical expenditures covered by employer-provided health insurance or Medicare in the MEPS, leading to $(q^{EMP}, q^{MCR}) = (0.625, 0.438)$.

4.1.5 Government policy

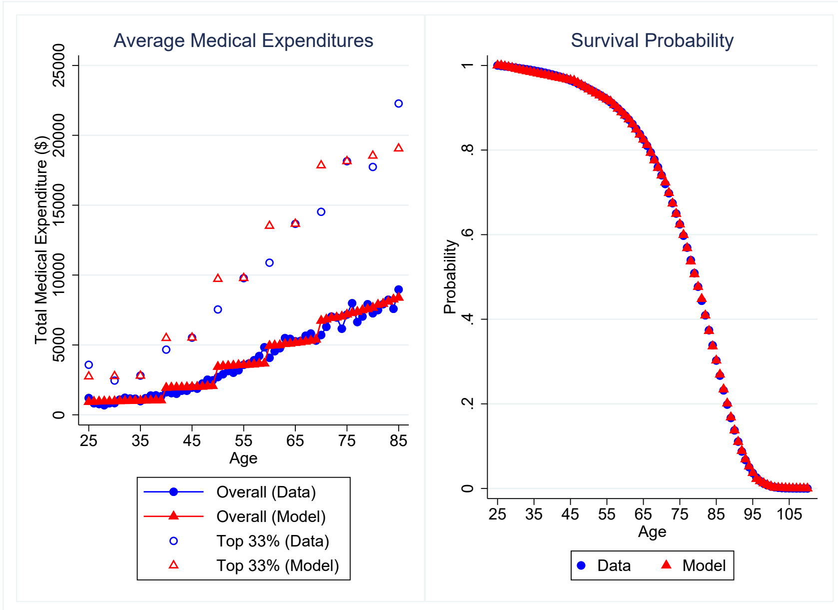
Social Security benefits are modelled in line with the Social Security system in the United States. Specifically, Social Security benefits are given by the following formula:

$$ss(\bar{e}) = \begin{cases} 0.9 \times \bar{e} & \text{if } \bar{e} < \$9,132 \\ \$8,219 + 0.32 \times (\bar{e} - \$9,132) & \text{if } \$9{,}132 \leq \bar{e} < \$55,032 \\ \$23,199 + 0.15 \times (\bar{e} - \$55,032) & \text{if } \bar{e} \geq \$55,032, \end{cases}$$

where $\bar{e}$ denotes the average of the past 35 highest annual earnings. This formula is based on the actual formula used in the United States in 2010, – the year for which the model is calibrated. In the model, the

[15]These payments include medical provider visits, hospital events, dental visits, vision aid, home healthcare, other medical equipment and services, and prescribed medicines.

Figure 6: Comparison on Medical Expenditures and Survival Probability (Data & Model)



Notes: Data source for medical expenditures and survival probability are the MEPS and Bell and Miller (2005), respectively. I stop plotting the average total medical expenditures at age 85 because age is capped at 85 in the MEPS.

average past earnings $\overline{e}$ is calculated following French (2005) as

$$\overline{e}' = \overline{e} + \frac{\min\{e, e^{ss}\}}{35}$$

for the first 35 years, i.e. up to age 59, where e^{ss} is the upper bound of taxable labor earnings, which is set at $e^{ss} = \$106,800$.

After that, average past earnings are updated only if new earnings exceed the current average past earnings:

$$\overline{e}' = \overline{e} + \max\left\{0, \frac{\min\{e, e^{ss}\} - \overline{e}}{35}\right\},$$

where $\overline{e}'$ is the updated average past earnings. Under this formula, the maximum amount of benefits is $\$35,739$.

The normal retirement age is set at 66, so that $j_R = 42$. This choice is based on the fact that the normal retirement age was 66 for most elderlies in 2010.[16] As I emphasized in the previous section, individuals can

[16]This eligibility criteria is for those who were born between 1943 and 1954 – the 1943-1954 cohorts. However, the normal

Table 2: Calibration Results

Parameter	Value	Target Moment	Data	Model
μ_θ	-3.896	Total employment rate at age 60	0.766	0.773
σ_θ	2.115	Total employment rate at age 45	0.948	0.943
ψ	0.377	Part-time employment rate at age 60	0.127	0.118
ζ	-13.40	Employment rate at age 75	0.132	0.113
b_1	$5,505$	The ratio of the median value of asset at age 85 to age 80	0.958	1.005
λ_2	0.042	Balance the government budget constraint	–	–
A	0.485	Normalize the aggregate output to 1	–	–

claim benefits before the normal retirement age. Following the current United States Social Security system, the age at which individuals can start to claim is 62. If they do, the benefits are reduced by the Actuarial Reduction Factor (ARF). The discount rate differs depending upon when recipients receive benefits. More concretely, their pension benefits drop by 25%, 20%, 13.3%, and 6.7% if they begin claiming at age 62, 63, 64, and 65, respectively. However, an earnings test applies if they receive benefits and work while they are below the normal retirement age. The earnings threshold level was $14,160 in 2010 and $1 of benefits for every $2 of earnings in excess of the exempt amount is withheld until all the pension benefits are exhausted. If benefits are withheld between ages 62 and 64, then benefits in the future will be raised by 6.7% each year.[17] On the other hand, pension benefits are increased through the Delayed Retirement Credit (DRC) if they claim later. The benefits are raised by 8.0% for every year up to age 70. At age 70 and older, however, the benefits are no longer adjusted. I assume that no individuals aged 70 or older claim.[18]

The Social Security tax rate τ^{ss}, which is imposed on $\min\{e, e^{ss}\}$, is set at $\tau^{ss} = 10.6\%$. The Medicare tax rate τ^{MCR} is set at $\tau^{MCR} = 2.9\%$. Both tax rates are according to United States law. The consumption tax rate τ^c is set at $\tau^c = 5\%$, following the literature (e.g., Mendoza et al. (1994)). For income taxation, parameters λ_0 and λ_1 are set as $(\lambda_0, \lambda_1) = (0.258, 0.768)$, following Gouveia and Strauss (1994). Parameter λ_0 is set to balance the government budget constraint.

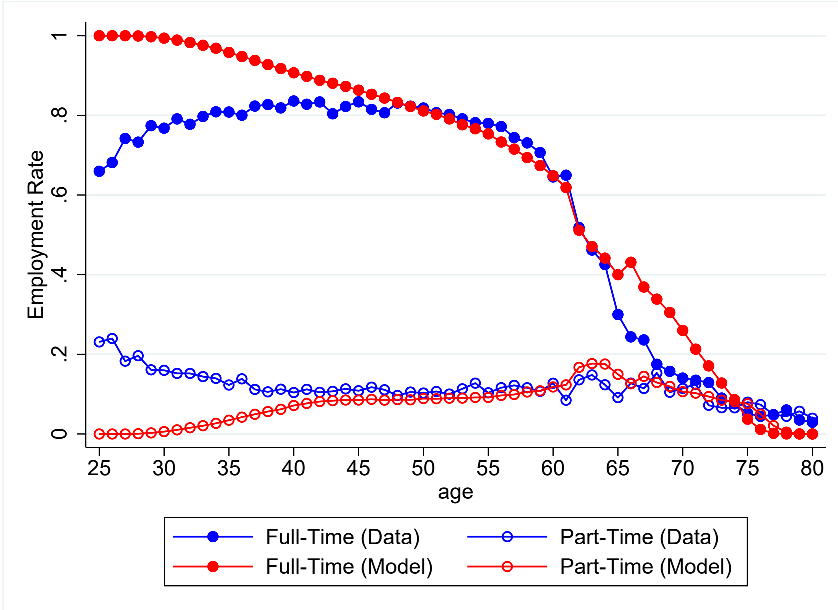
Finally, government spending G and government debt D are set as 20% and 40% of aggregate output, respectively. The value of the consumption floor is $4,972 in 2010 United States dollars as estimated in French and Jones (2011).

retirement age has been raised gradually for younger cohorts. For example, it is 67 for the 1960 cohort.

[17]Since keeping track of when individuals claim pension benefits and how much of their income is withheld is difficult, I approximate the actual adjustment following İmrohoroğlu and Kitao (2012).

[18]In reality, some elderlies claim pension benefits after age 71, but this fraction is tiny. According to the United States Social Security Administration, the average percentage was 1.02% in 2010.

Figure 7: Full-Time and Part-Time Employment Rates over the Life Cycle (Data & Model)



Notes: Data source is the IPUMS.

4.2 Model Performance

How well does the calibrated model explain employment rates, especially for elderlies? Figure 7 plots full-time and part-time employment rates over the life cycle in the data and the calibrated model. Overall, the model fits the employment rates closely over the life cycle. Specifically, the model captures the corresponding rates for individuals aged 66 and older well. The full-time employment and part-time employment rates between ages 70 and 80 are 9.50% and 6.29% in the model, which are close to the corresponding values, 7.20% and 6.76%, in the data, respectively.[19]

5. Simulating the Aging Economy

This section simulates the United States economy of 2050 using the calibrated model presented in Sections 3 and 4 and examines the sustainability of the Social Security system. Section 5.1 explains how the aging economy is simulated. Sections 5.2 and 5.3 simulate the aging economy without and with Social Security reforms, and quantify the impact of improving health status and increasing old workers on the tax burden

[19] The reason why the employment rate in the calibration is lower than what I show in Section 2 is that some data miss information on how many hours are worked.

Table 3: Health Status Depreciation (The Simulated Economies of 2010 and 2050)

Description	Parameter	2010	2050
Health status depreciation (Age 44 and younger)	κ^1	0.0012	0.0008
Health status depreciation (Ages 45 to 49)	κ^2	0.0032	0.0023
Health status depreciation (Ages 50 to 54)	κ^3	0.0032	0.0027
Health status depreciation (Ages 55 to 59)	κ^4	0.0057	0.0036
Health status depreciation (Ages 60 to 64)	κ^5	0.0084	0.0060
Health status depreciation (Ages 65 to 69)	κ^6	0.0128	0.0098
Health status depreciation (Ages 70 to 74)	κ^7	0.0186	0.0147
Health status depreciation (Ages 75 to 79)	κ^8	0.0247	0.0199
Health status depreciation (Ages 80 to 84)	κ^9	0.0337	0.0289
Health status depreciation (Ages 85 to 89)	κ^{10}	0.0379	0.0400
Health status depreciation (Ages 90 to 94)	κ^{11}	0.0298	0.0368
Health status depreciation (Ages 95 to 99)	κ^{12}	0.0134	0.0218
Health status depreciation (Age 100 and older)	κ^{13}	0.0030	0.0082

needed to sustain the Social Security system.

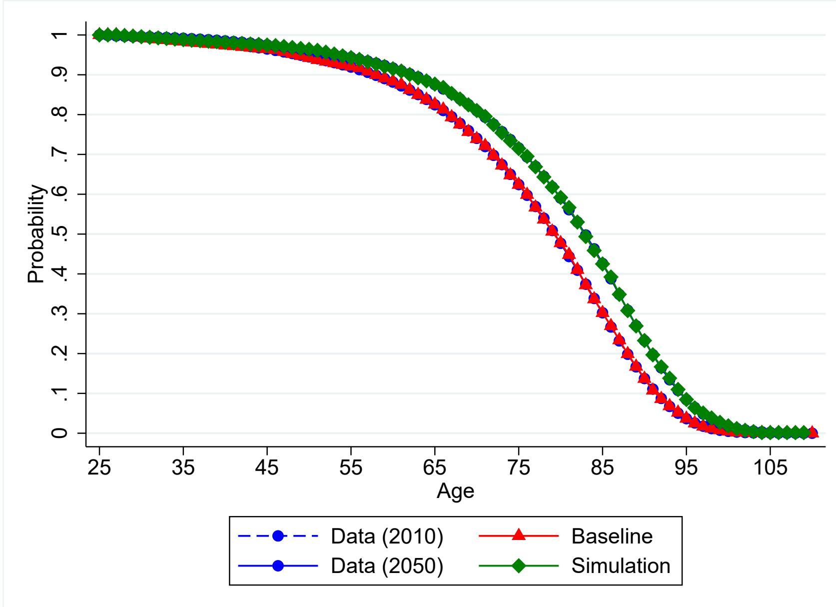
5.1 The Aging Economy

To simulate the aging economy of 2050, two exogenous driving forces are considered. First, the growth rate of new cohorts falls to 0.0026 to closely match the projected old-age dependency ratio in 2050. Second, health status depreciation κ_j is recalibrated in the same manner as in Section 3. The target moments are survival probabilities for males in 2050 calculated from the life-table of Bell and Miller (2005). Table 3 compares health status depreciation by ages calibrated to the 2010 and the 2050 economies. Evidently, health status depreciation in 2050 is lower than in 2010 for age groups younger than 85.[20] Thus, the level of health status at age 45, 60, and 75 in the 2050 economy is close to that of age 39, 55, and 71 in the 2010 economy, respectively. The new health status depreciation schedules can replicate the survival probabilities according to Figure 8.[21]

[20] On the other hand, health status depreciation at age 85 is higher in the simulation. The reason is that the projected survival probabilities for these age groups is as high as in 2010.

[21] In contrast, medical expenditures marginally changes in the simulation, suggesting that the impact of the standard deviation of medical shocks is predominant.

Figure 8: Survival Probability (The Simulated Economies of 2010 and 2050)



5.2 Simulation I: No Social Security Reform

5.2.1 Main findings

Figure 9 plots full-time and part-time employment rates over the life cycle for the simulated economies of 2010 and 2050. The 2050 economy has full-time workers' employment rates higher than those in the 2010 economy for those aged 45 and older; part-time workers' employment rates are higher only for individuals aged 70 and older. As the second column of Table 4 displays, the employment rate for all workers aged 70-80 increases from 15.8% in 2010 to 32.5% in 2050, marking a significant increase. This striking increase is mostly driven by lower health status depreciation in 2050, which makes individuals healthier and decreases their disutility of labor.

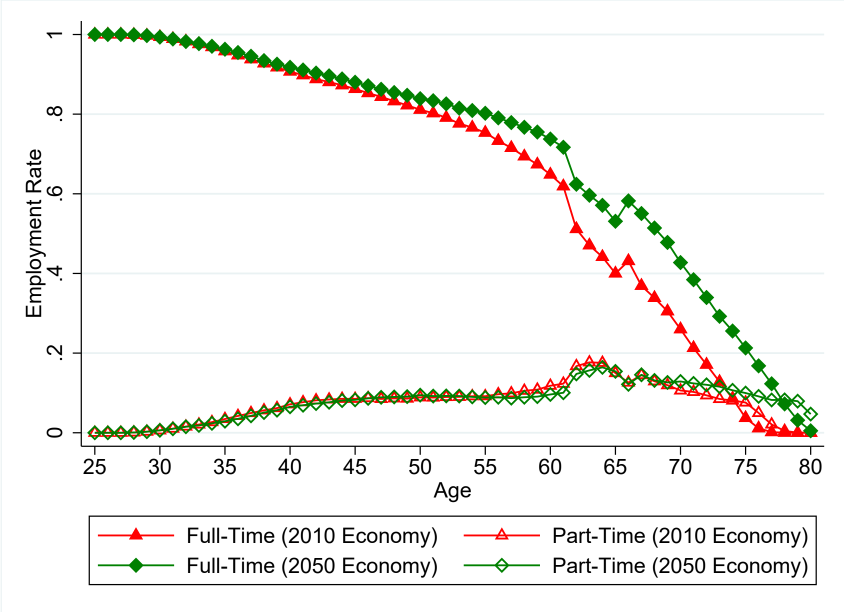
Table 4 also reports the fiscal cost that is required to sustain the Social Security system. The fiscal cost is defined as the additional rate of income tax, denoted by τ^{I*} to balance the budget.[22] In the 2050 economy without any Social Security reform, the government would have to impose an additional 5.87% income tax.

[22] Thus, the new government budget constraint is given by

$$G+\left[(1+r)D+\sum_{\mathbf{x}} ss(\mathbf{x})+\sum_{\mathbf{x}} tr(\mathbf{x})+q^{EMR}\sum_{\mathbf{x}} m(\mathbf{x})\right]\mu(\mathbf{x})=\sum_{\mathbf{x}}\left[\tau^{I}\left[e+ra\right]+\tau^{I*}\left(e+ra\right)+\tau^{ss}\min\left\{e,e^{ss}\right\}+\tau^{c}c(\mathbf{x})\right]\mu(\mathbf{x})+D'.$$

In addition to the government budget constraint, minor modification of the individuals' problem is required. But, this modification is straightforward, so, I omit explanation of it.

Figure 9: Full-Time and Part-Time Employment Rates over the Life Cycle (The Simulated Economies of 2010 and 2050)



This additional tax and the relatively small size of young working population due to population aging would decrease both capital per capita and labor per capita. In particular, labor per capita would decrease by more than 10%. This would lead to a lower interest rate and higher wage rate compared to the 2010 economy.

In summary, the government would require a fairly high additional tax to sustain the current Social Security system even though the number of old workers would increase substantially.

5.2.2 Role of old workers

The next simulation investigates how important old workers are to mitigate the fiscal burden. To isolate the impact of old workers, a counterfactual simulation is conducted where old individuals are forced to leave the labor market at age 70. Once retired, individuals are assumed to never return to the labor market as in the model of İmrohoroğlu and Kitao (2012).

The third column of Table 4 summarizes the results of the counterfactual simulation with a mandatory retirement age of 70.[23] Because the mandatory retirement is binding for some individuals, the number of old workers becomes smaller, which gives rise to a heavier tax burden. In the counterfactual simulation where workers aged 70 and older are absent, the government would have to levy a tax of 7.90% on income,

[23]Incidentally, introducing this system might potentially induce a larger fraction of individuals to work before they turn 70. However, I find that this impact would be modest.

Table 4: Results of The Simulated Economies of 2010 and 2050

	2010	2050			
Old workers (Age 70 and older)	Yes	Yes	No	Yes	No
Health Status	Yes	Yes	Yes	No	No
Capital per capita	–	-4.56%	-13.5%	-13.1%	-18.0%
Labor per capita	–	-12.1%	-16.2%	-15.4%	-17.9%
Equilibrium interest rate	6.35%	5.60%	6.05%	6.10%	6.36%
Equilibrium wage rate	–	$+2.99\%$	$+1.14\%$	$+0.97\%$	-0.04%
Total employment rate (Ages 70-80)	15.8%	32.5%	0.00%	19.1%	0.00%
Full-time employment rate (Ages 70-80)	9.50%	22.5%	0.00%	12.1%	0.00%
Additional tax on income	–	5.87%	7.90%	8.28%	9.52%

Notes: The second and the third rows present the cases of whether old workers are present ("Yes") or absent ("No") in the labor force and whether improving health status is considered ("Yes") or not ("No"), respectively. The percentage values for capital per capita, labor per capita, the equilibrium interest rate, and the equilibrium wage rate denote the difference from the simulated economy of 2010.

i.e. a 2.03 percentage point increase compared to the original case of no such mandatory retirement. This additional tax would adversely affect capital per capita and labor per capita. Hence, the fiscal burden would be substantially heavier if old workers must leave the labor market from age 70 onwards. This result points to the important role of old workers for the sustainability of the Social Security system.

5.2.3 Role of improving health status

The key feature of the model is the presence of health status that affects medical expenditures and disutility of labor as well as survival probability. To quantify the role of health status, an alternative counterfactual simulation is conducted where health status remains the same as the level in the simulated economy of 2010. To focus on the role of health status in medical expenditures and disutility of labor, the survival probability is assumed to be independent of health status in this exercise and is set directly to the levels reported in Bell and Miller (2005).

The last two columns of Table 4 summarize the impact of the aging economy with no improving health status. Relative to the case of improving health status where the employment rate for all workers aged 70-80 increases to 32.5% in 2050, in the case of no improving health status this employment rate still increases from the level of 2010, but only modestly, to 19.1%. Due to the modest increase in the total employment rate, the government has to raise the income tax by 8.28 percentage points to sustain the Social Security system, which is significantly higher than the 5.87 percentage point increase in the case of improving health status. In the case of no elderlies working after age 70, the additional tax becomes even higher, at 9.52%. But in this case the increase from the case of no mandatory retirement – 1.24 (=9.52-8.28) percentage points – is smaller than same cases that considers improving health status in addition– 2.03 (=7.90-5.87) percentage points. Hence, the role of old workers is diminished if one does not take into account improving health status. These results show that health status that is linked to medical expenditures and disutility of labor affects old workers' employment rate significantly and plays a crucial role in evaluating the sustainability of the Social Security system.

5.3 Simulation II: Social Security Reform

5.3.1 Main findings

The previous simulations suggest that the additional income tax rate required to sustain the current Social Security system would still be approximately 6% in spite of a larger fraction of old workers. To mitigate such a heavy fiscal burden, the government may implement Social Security reform. There are several policy candidates for reforming the Social Security system.[24] Here, as discussed in practice, raising the normal retirement age by 4 years is considered.[25] Under this reform, individuals can receive the full amount of Social Security benefits at age 70. This reform affects the benefit payment. Following İmrohoroğlu and Kitao (2012), I assume that if individuals claim earlier, their Social Security benefits are cut by a factor of 1.32. The number of 1.32 comes from the Social Security system in the baseline model. In the status quo, individuals' Social Security benefits will increase by 32%$(= 8\% \times 4)$ if they claim at age 70.

The first and the second columns of Table 5 present the effect of raising the normal retirement age when old workers are in the labor force. Unsurprisingly, this reform reduces the fiscal burden. The additional tax rate required to sustain the Social Security system is reduced to 3.37% under the reform from 5.87% with no reform. Since Social Security benefits are cut, workers respond by working more and saving more for consumption. Interestingly, per capita labor and capital increase by 1.08% and 0.28%, respectively, under the reform. Since capital increases more than labor, the real interest rate falls slightly while the wage rate

[24] As mentioned in the literature review, Kitao (2014) proposes four options to make fiscal policy self-sustaining: I) tax increase, II) benefit cut, III) raising the normal retirement age, and IV) introducing a means test in calculating Social Security benefits. She finds that all of the options are effective in terms of the sustainability of Social Security.

[25] İmrohoroğlu and Kitao (2012) conduct an experiment in which early retirement age is raised. I did a similar analysis. More concretely, I consider an extreme case where early retirement age is abolished. The simulation results indicate that this reform raises the fiscal burden, as in İmrohoroğlu and Kitao (2012), even when old workers are present. The reason is that spending on Social Security would increase as individuals cannot claim earlier and this impact is predominant. Detailed results are available upon request.

Table 5: Results of The Simulated Economy of 2050 with(out) Social Security Reform

Old workers (Age 70 and older)	Yes		No		Yes		No	
SS Reform	No	Yes	No	Yes	No	Yes	No	Yes
Health Status	Yes	Yes	Yes	Yes	No	No	No	No
Capital per capita	–	+1.08%	–	+1.26%	–	+1.59%	–	+0.09%
Labor per capita	–	+0.28%	–	−0.03%	–	+0.14%	–	+0.02%
Equilibrium interest rate	5.60%	5.53%	6.05%	5.93%	6.10%	5.97%	6.36%	6.27%
Equilibrium wage rate	–	+0.29%	–	+0.46%	–	+0.52%	–	+0.35%
Total employment rate (Ages 70-80)	32.5%	33.9%	0.00%	0.00%	19.1%	20.1%	0.00%	0.00%
Full-time employment rate (Ages 70-80)	22.5%	23.7%	0.00%	0.00%	12.1%	12.9%	0.00%	0.00%
Additional tax on income	5.87%	3.37%	7.90%	5.31%	8.28%	5.59%	9.52%	6.84%
Welfare	–	3.86%	–	3.88%	–	4.08%	–	4.11%

Notes: The second row presents the case where the government raises the normal retirement age by 4 years ("Yes") or the government does not implement any policy for Social Security ("No"). The first and third rows show whether old workers are present ("Yes") or absent ("No") in the labor force and whether improving health status is considered ("Yes") or not ("No"), respectively. The percentage values for capital per capita, labor per capita, the equilibrium interest rate, and the equilibrium wage rate denote the difference from the case of "No SS Reform". Welfare is defined as the fraction of lifetime consumption that individuals in the initial period would be willing to give up to live in the given economy rather than one where the Social Security system is not reformed.

rises.

In addition to measuring the fiscal burden, it is useful to evaluate the reform using individuals' welfare. The welfare gain of the reform is defined as the fraction of lifetime consumption that individuals in the initial period would be willing to give up to move to the economy with the reform from one without reform. The welfare gain of extending the retirement age from 66 to 70 is computed as 3.86%, which is significant in light of the relatively small welfare costs of business cycles reported in the literature.

5.3.2 Role of old workers

It is well known in the literature that social security reforms such as increasing the normal retirement age, reduce the fiscal cost of sustaining the Social Security system and improves welfare. However, most of the literature has not considered the role of old workers, especially those aged 70 or older, in extending the normal retirement age. This section sheds light on this aspect and conducts a simulation in which individuals aged 70 and older are retired and no longer work in order to isolate the role of old workers.

The third and fourth columns of Table 5 show the simulation results of this case. As in the previous case, this reform reduces the fiscal burden and raises individuals' welfare. However, the gap of the fiscal burden remains large even when the Social Security reform is implemented. The additional income tax required to sustain the Social Security system when old workers are absent is 5.31%, which is higher by 1.94%. Hence, even though the Social Security reform reduces spending on Social Security, old workers still play a significant role in sustaining the Social Security system.

5.3.3 Role of improving health status

The last four columns of Table 5 report the effects of Social Security reform when health status remains the same as in the 2010 economy. Even with the reform, ignoring the impact of health status results in an additional tax rate of 5.59%, which is higher than the 3.86% required in the case of taking health status into account. As in the case of no reform studied previously, ignoring the role of health status underestimates the role of old workers. Without the role of health status, the additional income tax rate rises by 1.25% (6.84%-5.59%) when individuals are forced to retire at age 70. This is in contrast to the 1.94% (=5.31%-3.37%) in the previous case, which considers the role of health status. Thus, even if improving health status is ignored, the importance of old workers does not disappear.[26]

6. Conclusion

This paper studies the quantitative role of old workers in the sustainability of Social Security using a computable overlapping generations model with heterogeneous agents in a general equilibrium framework. The model features a description of individuals' health status that can affect their incentives to work. In particular, health status is linked with their survival probabilities, medical expenditures, and disutility of labor. The model, calibrated to the United States economy of 2010, can explain non-targeted variables, especially the fraction of elderly workers.

The model is then used to simulate the aging economy of 2050. The findings are three-fold. First, the number of old workers increases notably in the aging economy because of improving health status. More precisely, the employment rate for all workers aged 70-80 becomes 2.06 times as high as the original level in 2010. Second, this sizable fraction of old workers reduces the fiscal cost significantly. Without them, the government would have to impose a substantially heavier tax to sustain the Social Security system. Third,

[26]Incidentally, my simulations suggest that improving health status itself would not amplify the effect of the Social Security reform. According to Table 5, the additional tax on income would be reduced at almost the same level regardless of whether improving health status is taken into account or not (2.50% and 2.69%). A possible reason is that there is no distribution of health status within a cohort, which would suppress the amplification impact on the Social Security reform.

the effects of old workers remain pronounced when implementing the Social Security reform of increasing the retirement age. Even if the government raises the retirement age by 4 years, the fiscal gap is still larger when old workers stop working than when they continue to work. These findings are uncovered only if improving health status is taken into account. If the level of health status is kept constant in the level of the 2010 economy, then the impact of old workers on the sustainability of the Social Security system is not evident.

The model has a high degree of heterogeneity, such as medical expenditures and disutility of labor, even within the same age cohort to capture the heterogeneity of individuals' incentives to work. Yet, the model assumes that every individual within the same age cohort faces the same survival probability. In reality, however, there exists a large inequality in life expectancy, as documented in Chetty et al. (2016). Taking the heterogeneity into account in the model may generate different quantitative implications for the sustainability of Social Security in the aging economy. One way of doing so is to incorporate health investment and its heterogeneity.[27] Although such an extension is beyond the scope this paper, the model developed in this paper could serve as a useful general equilibrium framework for analyzing the sustainability of the Social Security system with an emphasis on the role of old workers. I leave this to be explored in future research.

References

[1] Aguiar, Mark, and Erik Hurst. 2007. "Measuring Trends in Leisure: The Allocation of Time over Five Decades." *Quarterly Journal of Economics* 122 (3): 969-1006.

[2] Auerbach, Alan J., and Laurence J. Kotlikoff. 1987. *Dynamic Fiscal Policy*. Cambridge University Press.

[3] Bell, Felicitie C., and Michael L. Miller. 2005. Life Tables for the United States Social Security Area, 1900-2100. Actuarial Study No. 120. Office of the Chief Actuary, Social Security Administration.

[4] Capatina, Elena. 2015. "Life-Cycle Effects of Health Risk." *Journal of Monetary Economics* 74: 67-88.

[27] Several papers (e.g., Grossman (1972); Hall and Jones (2007); Scholz and Seshadri (2013); Ozkan (2017) embed health investment, which allows for endogenizing survival probability.

[5] Chetty, Raj, Michael Stepner, Sarah Abraham, Shelby Lin, Benjamin Scuderi, Nicholas Turner, Augustin Bergeron. and David Cutler. 2016. "The Association between Income and Life Expectancy in the United States, 2001-2014." *Journal of American Medical Association*, 315(16): 1750-1766.

[6] Conesa, J. C., Costa, D., Kamali, P., Kehoe, T. J., Nygard, V. M., Raveendranathan, G., and Saxena, A. 2018. "Macroeconomic Effects of Medicare." *Journal of the Economics of Ageing* 11, 27-40.

[7] Conesa, Juan C., and Dirk Krueger. 1999. "Social Security Reform with Heterogeneous Agents." *Review of Economic Dynamics* 2 (4): 757-795.

[8] De Nardi, Mariacristina, Eric French, and John Bailey Jones. 2016. "Medicaid Insurance in Old Age." *American Economic Review* 106 (11): 3480-3520.

[9] De Nardi, Mariacristina, Selahattin İmrohoroğlu, and Thomas J. Sargent. 1999. "Projected US Demographics and Social Security." *Review of Economic Dynamics* 2 (3): 575-615.

[10] De Nardi, Mariacristina, Svetlana Pashchenko, and Ponpoje Porapakkarm. 2018. "The Lifetime Costs of Bad Health." Unpublised.

[11] Díaz-Gimenez, Javier, and Julian Díaz-Saavedra. 2009. "Delaying Retirement in Spain." *Review of Economic Dynamics* 12 (1): 147-167.

[12] Engbom, Niklas. 2019. "Firm and Worker Dynamics in an Aging Labor Market." Unpublished.

[13] Fan, Xiaodong, Ananth Seshadri, and Christopher Taber. 2018. "Estimation of a Life-Cycle Model with Human Capital, Labor Supply and Retirement." Unpublished.

[14] French, Eric. 2005. "The Effects of Health, Wealth, and Wages on Labour Supply and Retirement Behaviour." *Review of Economic Studies* 72 (2): 395-427.

[15] French, Eric, and John Bailey Jones. 2011. "The Effects of Health Insurance and Self-Insurance on Retirement Behavior." *Econometrica* 79 (3): 693-732.

[16] Gouveia, Miguel, and Robert P. Strauss. 1994. "Effective Federal Individual Income Tax Functions: An Exploratory Empirical Analysis." *National Tax Journal*: 317-339.

[17] Grossman, Michael. 1972. "On the Concept of Health Capital and the Demand for Health." *Journal of Political Economy* 80 (2): 223-255.

[18] Hall, Robert E., and Charles I. Jones. 2007. "The Value of Life and the Rise in Health Spending." *Quarterly Journal of Economics* 122 (1): 39-72.

[19] Heathcote, Jonathan, Fabrizio Perri, and Giovanni L. Violante. 2010. "Unequal We Stand: An Empirical Analysis of Economic Inequality in the United States, 1967–2006." *Review of Economic Dynamics* 13 (1): 15-51.

[20] Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L. Violante. 2010. "The Macroeconomic Implications of Rising Wage Inequality in the United States." *Journal of Political Economy* 118 (4): 681-722.

[21] İmrohoroğlu, Selahattin, and Sagiri Kitao. 2009. "Labor Supply Elasticity and Social Security Reform." *Journal of Public Economics* 93.(7-8): 867-878.

[22] İmrohoroğlu, Selahattin, and Sagiri Kitao. 2012. "Social Security Reforms: Benefit Claiming, Labor Force Participation, and Long-Run Sustainability." *American Economic Journal: Macroeconomics* 4 (3): 96-127.

[23] Kitao, Sagiri. 2014. "Sustainable Social Security: Four options." *Review of Economic Dynamics* 17 (4): 756-779.

[24] Kotlikoff, Laurence J., Kent Smetters, and Jan Walliser. 1999. "Privatizing Social Security in the United States—Comparing the Options." *Review of Economic Dynamics* 2(3): 532-574.

[25] Kotlikoff, Laurence J., Kent Smetters, and Jan Walliser. 2007. "Mitigating America's Demographic Dilemma by Pre-Funding Social Security." *Journal of Monetary Economics* 54 (2): 247-266.

[26] Kopecky, Karen A., and Tatyana Koreshkova. 2014. "The Impact of Medical and Nursing Home Expenses on Savings." *American Economic Journal: Macroeconomics* 6 (3): 29-72.

[27] Liang, James, Hui Wang, and Edward P. Lazear. 2018. "Demographics and Entrepreneurship." *Journal of Political Economy*, 126 (1): 140-196.

[28] Mendoza, Enrique G., Assaf Razin, and Linda L. Tesar. 1994. "Effective Tax Rates in Macroeconomics: Cross-Country Estimates of Tax Rates on Factor Incomes and Consumption." *Journal of Monetary Economics* 34 (3): 297-323.

[29] Milligan, Kevin, and David A. Wise. 2015. "Health and Work at Older Ages: Using Mortality to Assess the Capacity to Work across Countries." *Journal of Population Ageing* 8 (1-2): 27-50.

[30] Nishiyama, Shinichi, and Kent Smetters. 2007. "Does Social Security Privatization Produce Efficiency Gains?." *The Quarterly Journal of Economics* 122 (4): 1677-1719.

[31] Ozkan, Serdar. 2017. "Preventive vs. Curative Medicine: A Macroeconomic Analysis of Health Care over the Life Cycle." Unpublished.

[32] Pashchenko, Svetlana, and Ponpoje Porapakkarm. 2013. "Quantitative Analysis of Health Insurance Reform: Separating Regulation from Redistribution." *Review of Economic Dynamics* 16 (3): 383-404.

[33] Scholz, John Karl, and Ananth Seshadri. 2013. "Health and Wealth in a Life Cycle Model." Unpublished.

[34] Toossi, Mitra, and Elka Torpey. 2017. "Older Workers: Labor Force Trends and Career Options," Career Outlook, U.S. Bureau of Labor Statistics.

[35] Wong, Arlene. 2019. "Population Aging and the Transmission of Monetary Policy to Consumption." Unpublished.

Table A1: Moment Matching (Baseline)

Description	Data	Model
Survival Probability at age 45 in 2010	0.965	0.965
Survival Probability at age 50 in 2010	0.945	0.944
Survival Probability at age 55 in 2010	0.919	0.920
Survival Probability at age 60 in 2010	0.882	0.882
Survival Probability at age 65 in 2010	0.825	0.825
Survival Probability at age 70 in 2010	0.740	0.740
Survival Probability at age 75 in 2010	0.624	0.624
Survival Probability at age 80 in 2010	0.477	0.477
Survival Probability at age 85 in 2010	0.302	0.303
Survival Probability at age 90 in 2010	0.137	0.138
Survival Probability at age 95 in 2010	0.037	0.037
Survival Probability at age 100 in 2010	0.005	0.005
Survival Probability at age 105 in 2010	0.0003	0.0004
Average Medical Expenditure at Age 35	\$980	\$1,015
Average Medical Expenditure at Age 55	\$3,580	\$3,562
Average Medical Expenditure at Age 75	\$7,177	\$7,179
Average Value of Top 33% Medical Expenditure at Age 35	\$2,806	\$2,794
Average Value of Top 33% Medical Expenditure at Age 45	\$5,522	\$5,522
Average Value of Top 33% Medical Expenditure at Age 55	\$9,778	\$9,784
Average Value of Top 33% Medical Expenditure at Age 65	\$13,666	\$13,666
Average Value of Top 33% Medical Expenditure at Age 75	\$18,147	\$18,146

Appendix A: Calibration for Health Status Depreciation and Medical Shocks

In the baseline economy, I calibrate $\{\kappa_1, \kappa_2, \cdots, \kappa_{13}\}$, $\left\{\mu_{\xi_1}, \mu_{\xi_2}, \cdots, \mu_{\xi_5}\right\}$, σ_ξ, A^m, and γ. To calibrate these parameters, I choose the following moments, reported in Table A1. Clearly, survival probability for specific age groups can identify each age groups' health status depreciation. Furthermore, $\{A^m, \gamma\}$ can be pinned down by the average medical expenditures at age 55 and 75. Lastly, $\left\{\mu_{\xi_1}, \mu_{\xi_2}, \cdots, \mu_{\xi_6}\right\}$ and σ_ξ are sensitive to the rest of the moments. As reported in Table A1, my model does an excellent job in matching the moments.

Similarly, I recalibrate health status depreciation in the simulation. Recall that the parameters I change are $\{\kappa_1, \kappa_2, \cdots, \kappa_{13}\}$ only. Table A2 presents the details.

Table A2: Moment Matching (Simulation)

Description	Data	Model
Survival Probability at age 45 in 2050	0.975	0.977
Survival Probability at age 50 in 2050	0.961	0.962
Survival Probability at age 55 in 2050	0.944	0.942
Survival Probability at age 60 in 2050	0.917	0.917
Survival Probability at age 65 in 2050	0.875	0.876
Survival Probability at age 70 in 2050	0.810	0.810
Survival Probability at age 75 in 2050	0.716	0.716
Survival Probability at age 80 in 2050	0.590	0.590
Survival Probability at age 85 in 2050	0.426	0.426
Survival Probability at age 90 in 2050	0.233	0.232
Survival Probability at age 95 in 2050	0.084	0.084
Survival Probability at age 100 in 2050	0.018	0.018
Survival Probability at age 105 in 2050	0.002	0.002

Appendix B: Computation Method

I summarize the steps to solve for the stationary equilibrium on the discretized space of individuals.

Step 1: Guess a set of vales for the equilibrium variables, which consist of the interest rate r, wage rate w, an insurance premium for employer-provided health insurance p^{EMP}, a lump-sum transfer from bequests tr^*, and an additional tax on income τ^{I*} (only for the simulations).

Step 2: Solve the individual's problem and derive policy functions at each state.

Step 3: Compute the distribution of individuals across states.

Step 4: Compute aggregate labor and aggregate capital from (10) and (11). Then, calculate the interest rate and wage rate from (6) and (7) and check if they are close to the guessed values. Also, verify if equilibrium conditions (4), (5), and (8) are satisfied for the other equilibrium variables. If not, update the guess for the equilibrium variables and return to **Step 2**.