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

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June 4, 2020

Abstract

An aging economy is widely believed to increase the recipients of Social Security and thus increase a fiscal burden. However, since health condition for elderlies is better and it may continue in future, the number of elderly workers may increase. This paper studies the quantitative role of old workers for 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 to incorporate health linked with 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 the Social Security reform is implemented. It also highlights a crucial role of projected future heath in quantifying the fiscal cost.

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1. Introduction

Population aging has advanced in developed countries, and the United States is not an exception. In 1960, the old-age dependency ratio – a ratio of individuals aged 65 and older to those aged 25 to 64 – was only 19.4%. But, the ratio increased and reached 24.7% in 2010, and the United Nations projects that the corresponding ratio will hit 45.3% in 2050.[1] An imminent issue on 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.

A main argument of this paper is that current and future elderlies are not the same elderlies in the past. In my paper, I define elderlies as those who age 70 and older. Evidence suggests that elderlies has become healthier for the last 35 years. Concurrently, a fraction of elderly workers has gradually increased. In 2015, an employment rate for males aged from 70 to 80 is 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, contribution of old workers to the sustainability of Social Security will likely become larger as the economy is aging.

Against this background, this paper addresses two specific questions. First, if old individuals live healthier, what the elderlies' work decision will be in the aging economy? Will they stay in the labor market and work longer than the previous generations as they are aging? Second, what will be the impact of these old workers' decisions for sustaining the Social Security system? Will it mitigate the fiscal cost to sustain Social Security significantly? To my best of 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 of health especially for old individuals. The model, calibrated to the United States economy of 2010, successfully replicates employment rates over the life-cycle, espe-

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

[2]Another dimensions in regards to aging are the 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 from "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 would increase up to 4.9% in 2036.

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

cially 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 and the increase in the employment rate reduces the fiscal burden significantly. The role of old workers remains stark if it accompanies the Social Security reform. It is the incorporation of improving health in the model that generates these large impacts. Actually, the impacts would be diminished if improving health were not taken into account.

The detailed description of health in the model is as follows. Health is assumed to have a linkage with disutility of labor and medical expenditures. Specifically, if health is worse, disutility of labor and medical expenditures are higher. In addition, health is assumed to be closely related to individuals' survival probability. By using this relationship, a change in health in future can be calibrated by exploiting the projected survival probability in the aging economy. This rich description of health 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, a firm, and a government. In each period, new individuals enter the economy and die depending on survival probabilities. In the beginning of the period, individuals' health 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 rule, they can collect Social Security benefits at the normal retirement age, but they can 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 rule. When working, individuals obtain labor earning 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 or/and a transfer from the government depending on eligibility. The government imposes taxes and issues a debt to finance these expenditures. Lastly, individuals make a decision on consumption and asset for the next period. A firm combines capital and labor according to a constant-return-to-scale production technology.

The model is solved for a stationary equilibrium and then carefully calibrated to the United States economy of 2010. Specifically, the population growth rate is set to match the old-dependency ratio, which is a key variable in the aging economy. In addition, parameters for health deprecations 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 depreciations drop in the 2050 economy. I then examine how many old workers there will be and how many taxes the government will have to impose to sustain the Social Security system.

The simulation results indicate that a fraction of old workers rises remarkably in the aging economy. In particular, relative to the 2010 economy, an employment rate for all workers with age 70-80 becomes 2.06 times as high as the original level in 2010. Because of improving health (i.e., lower values of health depreciations), 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 a smaller size of 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 instead of receiving Social Security benefits, this fiscal burden would be even heavier. The importance of old workers is still pronounced in the case of the 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 the social welfare gains. 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. To isolate its role, if the level of health is kept constant as in the 2010 economy, the presence of old workers becomes trifling. Since the number of old workers rises very modestly, the impact of old workers becomes smaller. Furthermore, even though the Social Security system is reformed, old workers do not play a significant role in reducing the fiscal cost and gaining social welfare more. Hence, taking into account future health improvement is crucial for understanding the relationship between old workers and the sustainability of the Social Security system in the aging economy.

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

[5] Auerbach and Kotlikoff (1987) is the first paper to develop this large-scale overlapping generations model. Many papers employ a richer version of Auerbach and Kotlikoff (1987) to address the issue on the Social Security reform (Conesa and Kruger (1999); Kotlikoff et al. (1999); Nishiyama and Smetters (2007); Imrohoroglu and Kitao (2009)).

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

This section briefly documents upward trends in employment rate for elderlies and health 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 employment rates for males between ages 70 and 80 for 30 years. The data source is the Integrated Public Use Microdata Series (IPUMS). As Figure 1 presents, employment rates for elderly males have increased gradually. In 1985, employment rate for these individuals was 13.7%. However, this fraction has reached 18.5% in 2015.

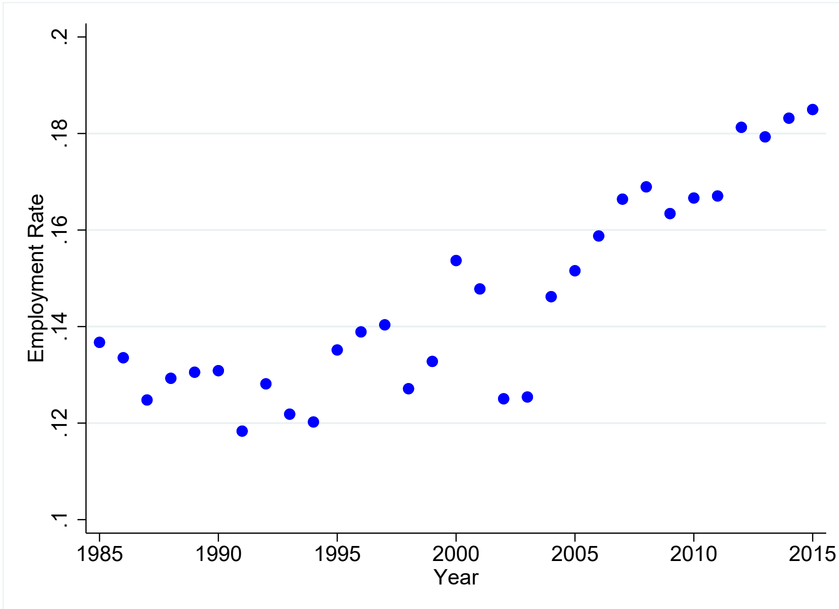
2.2 Health

Surprisingly, what the gradual increase in elderly workers can be attributed to is masked. My paper argues that improving health is potentially the main driving force. Figure 2 plots the mortality rates at age 70-80 in 1985 and 2015, according to the Human Mortality Database. As can be seen, the mortality rate declines more significantly from 1985 to 2015. The average decreasing rate is 2.66%, which is more than twice

[6] Imrohoroglu and Kitao (2012) is the only paper to incorporate health 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. They are independent of survival probability, which is hard to embed improving health into the model.

[7] De Nardi et al. (1999), Kotlikoff et al. (2007), and Imrohoroglu 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



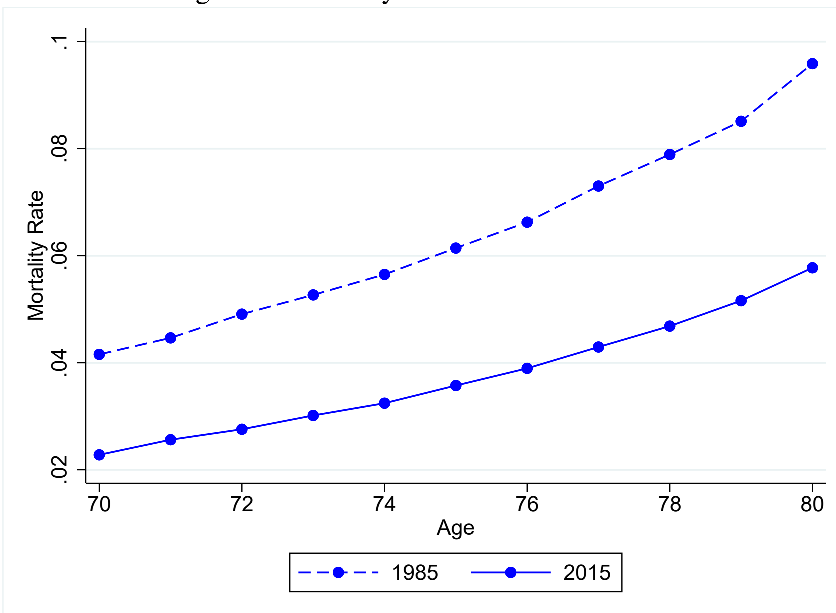
Notes: Data source is the Integrated Public Use Microdata Series.

as high as between 1955 and 1985 (1.18%). Furthermore, this decline is stark as males grow old. At age 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 in a particular age occur in 2015.[8] I call it the mortality-equivalent. Figure 3 shows the mortality-equivalent age of 2015 in a particular age. 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 with 1985 (2.25 years), suggesting that elderly males are much healthier in the last 30 years.[9] Since the mortality rates are projected to keep declining in future according to Bell and Miller (2005), improving health would potentially continue, which would induce a larger fraction of elderlies to work. The goal of this paper is to project elderly workers in future and explore how important they are in regards to 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.

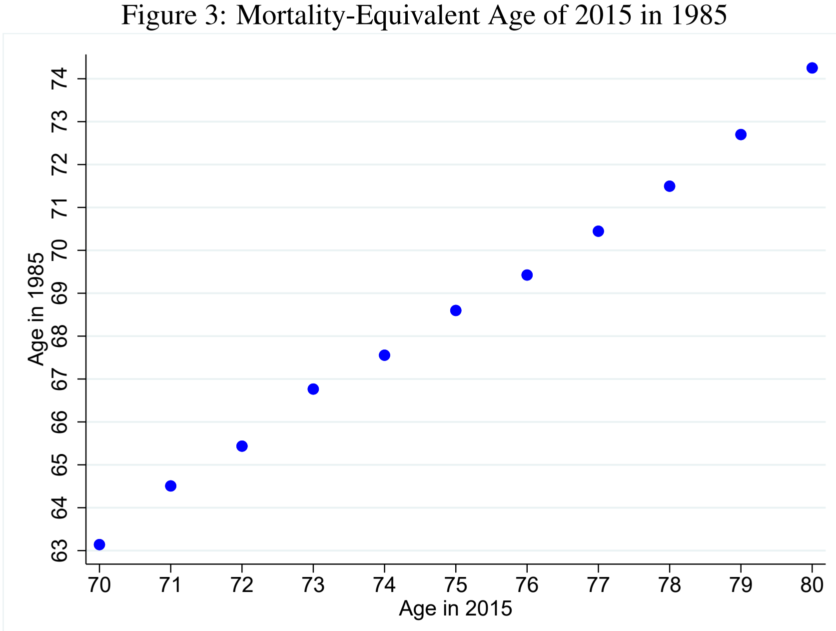
[9]Elderly females are healthier as well, but the magnitude from 1985 to 2015 is as large as from 1955 to 1985. The gap between the morality-equivalent age and the actual age is 3.40 years (1985-2015) and 4.21 years (1955-1985), respectively.

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 1980. Data source is the Human Mortality Database

3. Model

The model builds on a quantitative overlapping generations model, modified to incorporate health in a unique way. There are individuals, firms, and the government. The health of individuals changes as they get older. The health affects individuals' survival probabilities, medical expenditures, and disutility of labor. Thus, the health 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 and old workers. In the following, the model environment is described, which is followed by the 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 survives to the next age of $j+1$ with probability Φ_j. This survival probability depends on the health of individuals, which will be described shortly. The size of new cohort grows at a constant rate n. Let μ denote a population distribution.

3.1.2 Health

The health 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 depreciation, which is assumed to be identical across individuals of age j. Thus, health has no heterogeneity within a cohort.

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

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

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. The interpretation of the health shock ξ is a deterioration of health from the current level of h_j. But an underlying assumption is that the health recovers completely to the original level of h_j by taking medical services, which require the medical expense $m_j(\xi)$. This assumption allows the model to keep 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 affects individuals' disutility of labor, which will be specified below. Third, the health determines survival probabilities facing individuals. Specifically, following Scholz and Seshadri (2013) and Ozkan (2017), the survival probability facing the individual of age j depends solely on the current health h_j: $\Phi_j = \Phi(h_j)$. The survival probability is exogenously given. In practice, health could affect other key components such as labor productivity.[10] But, since a relationship between this type of health 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:

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

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

Following Imrohoroglu and Kitao (2012), my model incorporates Social Security claiming decision. 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 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 are calculated by individuals' average life-time earning $\bar{e}$.

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

Depending upon when they claim, the Social Security benefits is adjusted downward or upward. I present an explanation for the Social Security system and calculation of Social Security in the next section. Because they are allowed to work even though they collect Social Security benefits, individuals can decide whether to work every period.

The initial asset is 0 for every individual. Then, they can accumulate their assets with the market interest rate r. Their life-time 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 a taste for 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 this utility function in the next section.

Individuals are heterogeneous in following dimensions: age period j, assets a, health h_j, the average life-time earning $\overline{e}$, an idiosyncratic labor productivity shock ε, a taste shock θ, and a medical shock ξ. Let $\mathbf{x} = \left(j,a,h_j,\overline{e},\varepsilon,\theta,\xi\right)$. In each period, they make optimal decisions of $\{c,a',l\}$ and the claiming decision 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, a 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 insurance program, Medicare. Medicare is provided to those aged 65 or older and it covers a fraction q^{MCR} of the 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 the health insurance that covers a fraction q^{EMP} of the 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 two criteria: i) after-tax total income plus assets are below the minimum consumption level, denoted by $c_{\min}$ and ii) after-tax total income plus assets net of out-of-pocket medical expenditure are below $c_{\min}$. In addition, the government consumes G and pays the 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 the 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 earning is above the 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:

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

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 the homogenous good. An aggregate production function exhibits a constant return to scale:

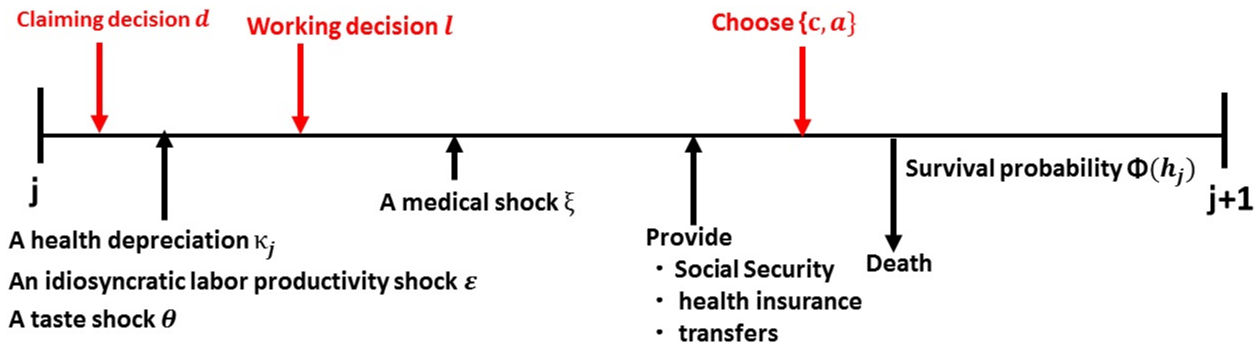
$$Y=AF(K,L)=AK^{\alpha}L^{1-\alpha},$$

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

Taking the first-order conditions yields

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

Figure 4: Model Timing



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

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, they can initially make a claiming decision d. Then, health depreciates by κ_j, and an idiosyncratic labor productivity shock ε and a taste shock for disutility from working θ arrive. Subsequently, individuals make the decision on working l. After this decision, a medical shock ξ hits and Social Security, Medicare and the government transfer are provided if they are eligible. Lastly, they choose consumption, and assets. Depending on survival probabilities, they 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

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

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

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

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

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

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

3.6 Stationary Equilibrium

I define a stationary equilibrium and a set of conditions that are satisfied in the model.

Definition: For a given set of population growth n and the 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 transfer of a bequest tr^{*}, and the distribution of individuals $\mu\left(\mathbf{x}\right)$ 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).
- An 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 the following.

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

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

- An 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 a calibration strategy and examines whether the calibrated model replicates employment rate especially for old workers, which is a 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 males only. There are two reasons for this choice. First, an employment rate for females has been risen significantly in the United States and the model abstracts from underlying driving forces. Second, a gap of an employment rate between males and females has shrunk significantly, so that the model considered in this paper can be regarded as the economy in which such a gap is 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 counts 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 the OECD statistics, a gap of labor force participation rate at age 15-64 between males and females is 25.9% in 1980. However, this gap falls down to 11.2% in 2010.

4.1.2 Preferences and technologies

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

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

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. Parameters ζ governs the elasticity of disutility of labor with respect to health for workers, and ψ is a relative weight of disutility of labor for part-time workers. An idiosyncratic shock to disutility of labor is introduced to reflect a 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 five free parameters, five target values are set: total employment rates at age 45 and 60; employment rate at age 75; and part-time employment rates at age 60. Albeit 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:

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

where b_1 denotes the weight of the bequest motive and b_2 is a constant. This function is commonly employed in the model incorporating bequest motives including Imrohoroglu and Kitao (2012). Parameter b_2 is set $b_2 = \$444,000$ in 2004 United States dollar 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 becomes close between the model and 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 ratios are the same as in Imrohoroglu and Kitao (2012). Finally, the technology level of the production function A is set so that the output becomes unity.

4.1.3 Labor earning

The age-specific labor productivity η_j is set by using wage per hour by age from the IPUMS. The sample is restricted to males aged 65 and younger, because age 66 has been the normal retirement age at which a number of 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 the 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. Labor productivity parameter η_j for age 66 and older is extrapolated by using the fitted curve.

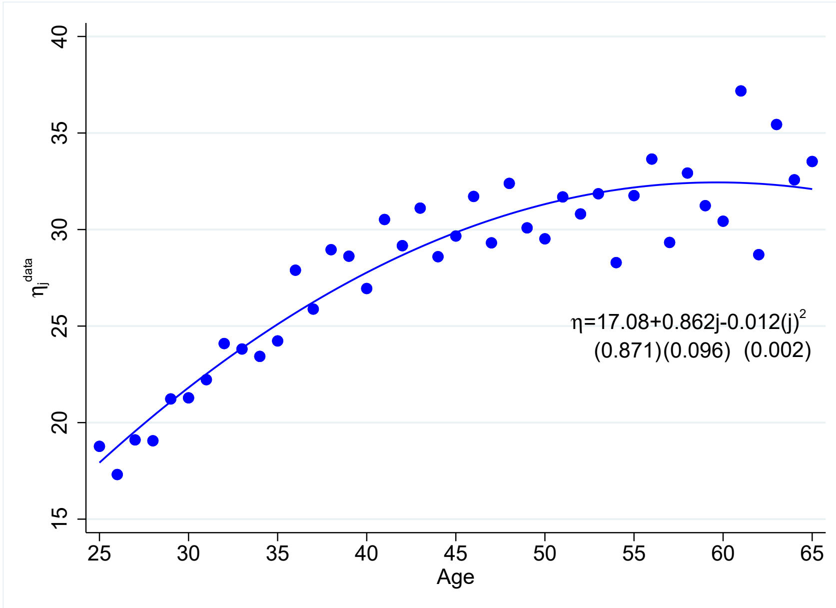
The idiosyncratic labor productivity shock ε is assumed to follow an AR(1) process in log. Following Heathcote et al. (2010), the AR(1) coefficient is set at 0.97 and the variance of the white noise is set at 0.018.[14]

[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 account, individual retirement accounts, stocks, the value of a farm or business, mutual funds, bonds and other assets less mortgages and other debts. The net worth is divided into a half for a married couple. The net wealth in the bins of age 78-82 and age 83-87 are regarded as that for age 80 and age 85, respectively.

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

[14]Heathcote et al. (2010) also focus on male hour wage 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 and insurance

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

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

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 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, 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 is

Table 1: Calibration Result of the Parameters

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

assumed to be age-dependent and can take five different values $\left\{\mu_{\xi_1}, \mu_{\xi_2}, \cdots, \mu_{\xi_5}\right\}$. 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 in a way that the model replicates the moments of 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 above 85. As medical expenses the total medical payments for males are 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 have 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 by different ages are used as the target moments. For the detail, see the Appendix A.

Table 1 reports the calibration result. As shown in Figure 6, with these calibrated parameter values the model fits well the data 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

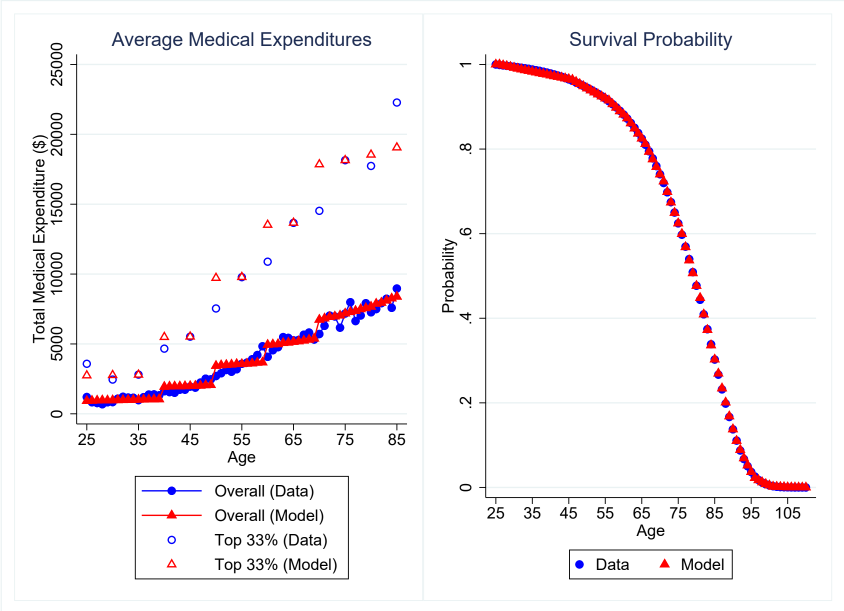
The Social Security benefit is modelled in line with the Social Security system in the United States. Specifically, the Social Security benefit is given by the following formula:

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

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

[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 above 85 in the MEPS.

following French (2005) as

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

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

After that, the average past earning is updated only if the new earning exceeds the current average past earning:

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

where $\overline{e}'$ is the updated average past earning. Under this formula, the maximum amount of the 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 is 66 for most of elderlies in 2010.[16] As I emphasize in the previous section, individuals

[16]This eligibility is for those who were born in 1943 or 1954 – 1943-1954 cohorts. However, the normal retirement age has been

Table 2: Calibration Result

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 80	0.958	1.005
λ_2	0.042	Balancing the government budget constraint	–	–
A	0.485	Normalizing the aggregate output as 1	–	–

can claim earlier before they turn the normal retirement age. Following the current United States Social Security system, the age at which they start to claim is 62. If they do, the benefits are reduced by the Actuarial Reduction Factor (ARF). The earliest age is 62. The discount rates differ depending upon when they receive. More concretely, their pension benefits drop by 25% (Age 62), 20% (Age 63), 13.3% (Age 64), and 6.7% (Age 65). However, the earning test applies if they receive the benefits and work during these periods. The earning threshold level is $\$14,160$ 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, benefits in the future will be raised by 6.7% each year.[17] On the other hand, pension benefits increase 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 then assume that none of individuals claims at age 70 or older.[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 the 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.

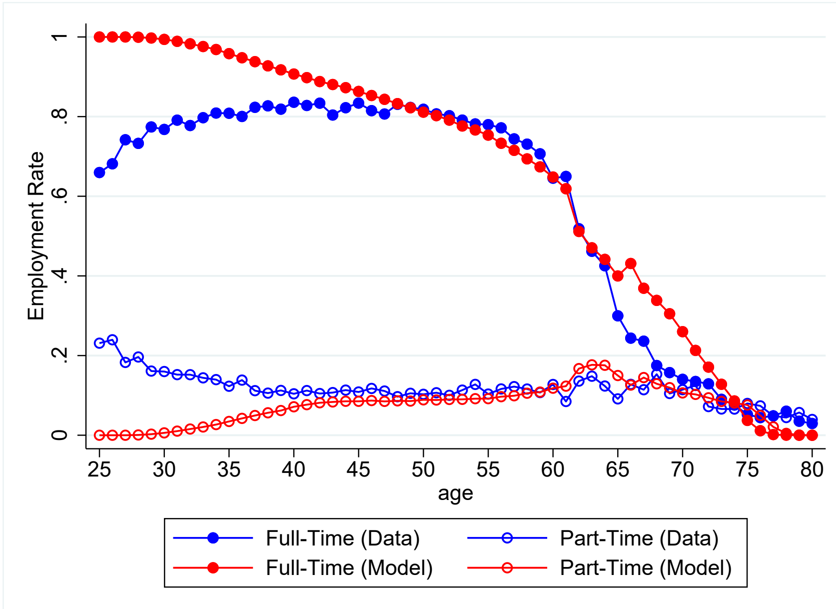
Finally, the government spending G and the government debt D are set as 20% and 40% of the aggregate output, respectively. The value of the consumption floor $\$4,972$ in 2010 United States dollar as estimated in French and Jones (2011).

raised gradually for younger cohorts. For example, it will become age 67 for the 1960 cohort.

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

[18]In reality, some of the elderlies claim pension benefits after age 71, but this fraction is tiny. According to the United States Social Security Administration, the averaged percentage is 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 par-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 well captures the corresponding rates for individuals aged 66 and older. 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% of the data, respectively.[19]

5. Simulating the Aging Economy

This section simulates the United States economy of 2050 by 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, respectively, and quantify the impact of improving health and old workers on the tax burdens

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

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

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

to sustain the Social Security system.

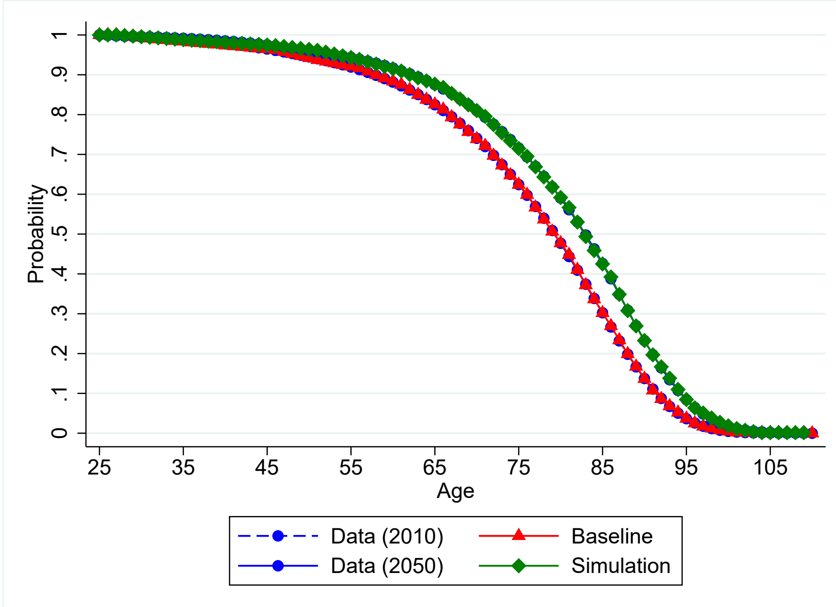
5.1 The Aging Economy

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 depreciations κ_j are recalibrated in the same manner as in Section 3. The target moments are survival probability for males in 2050 calculated from the life-table of Bell and Miller (2005). Table 3 compares health depreciations calibrated to the 2010 and the 2050 economies. Evidently, the health depreciations in 2050 are lower than those in 2010 for age groups younger than age 85.[20] Thus, the level of health 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 depreciations can replicate the survival probability according to Figure 8.[21]

[20]On the other hand, health depreciations at age 85 is higher in the simulation. The reason being that the projected survival probability at these periods 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 seems 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 economy of 2010 and that of 2050. The 2050 economy has full-time workers' employment rates higher than those in the 2010 economy for those with age 45 or older; part-time workers' employment rates are higher only for individuals with ages 70 or older. As the second column of Table 4 displays, an employment rate for all workers with age 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 depreciations in 2050, which make individuals healthy and decrease their disutility of labor.

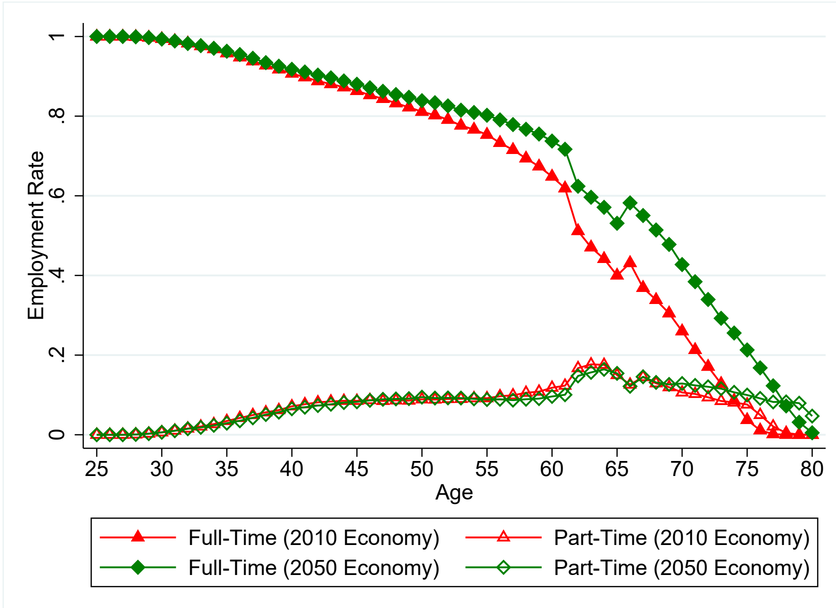
Table 4 also reports the fiscal cost that is required to sustain the Social Security system. The fiscal cost is defined as an additional rate of income tax, denoted by τ^{I*}.[22] In the 2050 economy without any Social Security reform, the government would have to impose a 5.87% additional income tax.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

[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, I require to modify individual's problem, but this modification is quite straightforward. So, I omit it.

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



tax and the relatively small size of young workers due to population aging would decrease both capital per capita and labor per capita. Especially, labor per capita would decrease by more than 10%. This would lead to lower interest rate and rise 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 Imrohoroglu and Kitao (2012).

The third column of Table 4 summarizes the results of the counterfactual simulations with the mandatory retirement age of 70.[23] Because the mandatory retirement is binding for some individuals, the number of old workers become lower, which would give 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 age 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	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 row and the third row present whether old workers are present ("Yes") or absent ("No") in the labor force and whether improving health is considered ("Yes") or not ("No"), respectively. Each percentage for capital per capita, labor per capita, the equilibrium interest rate, and the equilibrium wage rate denote a distance from the simulated economy of 2010.

i.e. 2.03 percent points increase than the original case of no such mandatory retirements. This additional taxes would adversely affect capital per capita and labor per capita. Hence, the fiscal burden would be fairly heavier if old workers must leave the labor market at age 70 onwards. This result points to an important role of old workers for the sustainability of the Social Security system.

5.2.3 Role of improving health

The key feature of the model is the presence of health that affects medical expenditures and disutility of labor as well as survival probability. To quantify the role of health, 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 for medical expenditures and disutility of labor, survival probability is assumed to be independent of health in this exercise and the survival probability is set directly at those reported in Bell and Miller (2005).

The last two columns of Table 4 summarizes the impact of the aging economy with no improving health. Relative to the case of improving health where employment rates for all workers at age 70-80 increase to 32.5% in 2050, in the case of no improving health these employment rates still increase from the levels of 2010 but only modestly to 19.1%. Due to the modest increase in the total employment rates, the government has to raise the income tax by 8.28 percentage points to sustain the Social Security system, which is significantly higher than 5.87 percentage points in the case of improving health. In the cases of no old workers older than age 70, the additional tax becomes even higher, given by 9.52% But in these cases the increases from the case of no mandatory retirement – 1.24 (=9.52-8.28) percentage points – is smaller than the same cases with improving health – 2.03 (=7.90-5.87) percentage points. Hence, the role of old workers are diminished without taking into account improving health. These results show that health that is linked to medical expenditures and disutility of labor affects old workers' employment rates significantly and plays a crucial role for 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 an additional income tax rate required to sustain the current Social Security system would be still approximately 6% in spite of a larger fraction of old workers. To mitigate such a heavy fiscal burden, the government may implement the Social Security reform. There are several policy candidates for the Social Security system reform.[24] Here, as discussed in practice, raising the normal retirement age by 4 years is considered.[25] Under this reform, individuals can receive a full amount of Social Security benefits at age 70. This reform affects the benefit payment. Following Imrohoroglu 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 presents the effect of raising the normal retirement age when old workers are in the labor force. Unsurprisingly, this reform reduces the fiscal burden. An 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, they respond by working more and saving more for consumption. Actually, per capita labor and capital increase by 1.08% and 0.28%, respectively, under the reform. Since the capital increases more than the labor, the real interest rate falls slightly while the wage rate increases.

[24] As mentioned in the literature review, Kitao (2014) proposes four options to make fiscal policy self-sustained: I) tax increase, II) benefit cut, III) raising the normal retirement age, and IV) introducing 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] Imrohoroglu 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. A simulation result indicates that this reform raises the fiscal burden as in Imrohoroglu and Kitao (2012) even when old workers are present. The reason being that spendings on Social Security would increase as individuals cannot claim earlier, whose impact seems predominant. The detailed result is available upon the 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	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 the third rows show whether old workers are present ("Yes") or absent ("No") in the labor force and whether improving health is considered ("Yes") or not ("No"), respectively. Each percentage for capital per capita, labor per capita, the equilibrium interest rate, and the equilibrium wage rate denote a distance from the case of "No SS Reform". Welfare is defined as a fraction of life-time consumption that individuals at the initial period would be willing to give up to live in an economy instead of when the Social Security system is not reformed.

In addition to the measure of a fiscal burden, it is useful to evaluate the reform by using individuals' welfare. A welfare gain of the reform is defined by a fraction of life-time consumption that individuals at the initial period would be willing to give up to move from the economy with the reform to that with no reform. The welfare gain of extending the retirement age from 66 to 70 is computed as 3.86%, which is significant in light of 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 the social security reform such as increasing the normal retirement age reduces the fiscal cost of sustaining the Social Security system and improves welfare. However, most of the literature has not considered role of old workers, especially those with age 70 or older, in the reform of extending the nominal retirement age. This section sheds light on this aspect and conducts a simulation in which individuals with age 70 or older are retired and no longer work to isolate the role of old workers.

The third and the fourth columns of Table 5 show the simulation result in such a case. As in the previous case, this reform reduces the fiscal burden and gains individuals' welfare. However, the gap of the fiscal burden remains large even when the Social Security reform is implemented. An 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 spendings on Social Security, old workers still play a significant role in sustaining the Social Security system.

5.3.3 Role of improving health

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

6. Conclusion

This paper studies the quantitative role of old workers for the sustainability of Social Security using a computable overlapping generations model with heterogeneous agents in a general equilibrium framework. The model features description of individuals' health that can affect their incentives to work. In particular, health 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 a 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. More precisely, an employment rate for all workers with age 70-80 become 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 fairly heavier tax to sustain the Social Security system. Third, the effects of old workers remain pronounced when the Social Security reform of increasing the retirement age is implemented. Even if the government raises the retirement age by 4 years, the gap of fiscal cost is still

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

larger depending upon whether old workers are present. These findings are uncovered only if improving health is taken into account. If the level of health is kept constant as in the 2010 economy, the impact of old workers on the sustainability of the Social Security system is not salient.

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' incentive to work. Yet, the model assumes that every individual within the same age cohort faces the same survival probability. In reality, however, there exists large inequality in life expectancy as documented in Chetty et al. (2016). Taking into account such a heterogeneity 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 emphasis on the role of old workers. I leave it to be explored in future research.

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Table A1: Moment Match (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 Depreciations 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 in specific age periods can identify each health capital depreciations. 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 depreciations in the simulation. Recall that parameters I change is $\{\kappa_1, \kappa_2, \cdots, \kappa_{13}\}$ only. Table A2 presents the detail.

Table A2: Moment Match (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 equilibrium variables, which consist of 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 individuals' 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 interest rate and wage rate from (6) and (7) and check if they are close to the guessed ones. Also, verify if equilibrium conditions (4), (5), and (8) are satisfied for the other equilibrium variables. If not, update guess for the equilibrium variables and return to **Step 2**.