

# Sustainable Social Security: Four Options\*

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## Abstract

Four policy options to make the social security sustainable under the coming demographic shift are presented; (1) increase the payroll taxes by 6 percentage points, (2) reduce the replacement rates by one-third, (3) raise the normal retirement age from 66 to 73, or (4) means test the benefits and reduce them one-to-one with income. While four policies all achieve the same goal, economic outcomes differ significantly. Options (2) and (3) encourage own savings and capital stock will be more than 10% higher than in the other two options. The payroll tax increase in option (1) discourages work effort, but means-testing the benefits in option (4) gives the worst labor disincentives, especially among the elderly.

**Keywords:** Social security reform and sustainability, general equilibrium, labor force participation, retirement age, demographic shift, overlapping generations

**J.E.L. classification codes:** E2, E6, H55, J2

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\*The views expressed in the paper are those of the authors and do not necessarily reflect those of the Federal Reserve Bank of New York or the Federal Reserve System.

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# 1 Introduction

The coming demographic shift will pose a significant fiscal challenge on the budget of the social security system. The long-run sustainability of the pension system is in question unless some form of reform is undertaken to close the budget gap that is expected to grow.

Life-expectancy has grown dramatically from 75 years in 1950 to 82 years in 2000 and the growth is expected to continue with the projection of 88 years by the end of the century. Birth rate has declined sharply during last decades and the total fertility rate fell from above 3.0 in 1950 to slightly above 2.0 in 2000. The dependency ratio is projected to rise rapidly from the current 22% and reach 38% in 2050 and 45% in 2100.<sup>1</sup> More retirees will receive benefits, while there will be relatively fewer workers who contribute to the system through payroll taxes on earnings. The policy debate and public concerns appear to be mostly based on the insufficient fund of the pension system imputed from simple accounting exercises. Economic distortions, however, that would emanate from fiscal adjustments to maintain the pay-as-you-go system could exacerbate the sustainability problem. For example, if the general government budget would absorb the imbalance and income taxes were to rise, it may discourage investment or work efforts, which reduces the level of economic activities and shrinks the tax base, requiring further increase in taxes, and so on. To quantify the effects of the demographic shift and fiscal consequences, we develop an economic model in which individuals make decisions on consumption, savings, labor participation and work hours over the life-cycle in a competitive production economy. Our model shows that the social security program, which currently runs a surplus of about 0.5% of GDP, can generate a sizeable deficit of more than 3.0% of GDP every year, when the economy is under the demographics projected for 2100 and no reform is undertaken.

The paper considers four policy options that would make the social security system self-financed and its budget balanced every year; (1) raise the social security tax by 6 percentage points, (2) reduce the replacement rates of the benefit formula by one-third, (3) increase the normal retirement age from 66 to 73, or (4) make the system means-tested and let the benefits decline one-to-one with income. All of these four options are shown to achieve the same goal of making the system self-financed. The economies, however, implied by alternative policies differ significantly from each other in terms of aggregate economic activities as well as the behavior

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<sup>1</sup>The dependency ratio is defined as the ratio of population above age 65 to that of age 20 to 64. Source: Bell and Miller (2005) for life expectancy and the Census for dependency ratio: <http://www.census.gov/population/www/projections/>.

of individuals along the life-cycle. Reducing the spendings through scaling down the benefit replacement rates and raising the normal retirement age will provide strong incentives to increase savings to supplement retirement consumption and the capital stock will be significantly higher than in the other two options. The higher payroll taxes will have negative work incentives and the participation rates in the first option will be much lower than in the second and third options. The average years of work is 44.7 years in option 1, while it is 46.8 and 46.3 years in options 2 and 3, respectively. The worst option, however, in terms of work disincentives, especially among the elderly is the last option of means testing the benefits. The labor force participation will plummet once individuals reach the normal retirement age and only 4.5% of those at age 65-85 will participate, while about 13 to 19% of those individuals would be in the labor force in other reforms.

This paper builds on the vast quantitative research on social security reforms and aging demographics in the tradition of general-equilibrium life-cycle models pioneered by Auerbach and Kotlikoff (1987).<sup>2</sup> Existing papers study effects of particular and often ad hoc reforms of the existing social security system. This paper presents a set of policy options that make the social security self-financed as the economy faces the coming demographic shift. The set encompasses the range of possible and debated reforms and we quantify the magnitude of changes in each option that would restore the long-run sustainability of the program, taking into account the responses to reforms in aggregate variables as well as life-cycle behavior of individuals.

Most papers in the quantitative general-equilibrium literature assume that labor supply is either exogenous or endogenous only in the intensive margin. Our model endogenizes labor supply in both intensive and extensive margins and examines the changes in participation as well as work hours in response to reforms. Recent exceptions are İmrohorođlu and Kitao (2011) and Díaz-Giménez and Díaz-Saavedra (2009). İmrohorođlu and Kitao (2011) incorporate endogenous participation as well as social security benefit claims and focuses on two particular reforms to change retirement ages. Díaz-Giménez and Díaz-Saavedra (2009) study the effects of reform of the Spanish pension system to raise the retirement age in a model with endogenous retirement decisions. Reforms are shown to affect both margins in different ways and exhibit a considerable degree of heterogeneity in the responses across them.

The rest of the paper is organized as follows. Section 2 presents the model

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<sup>2</sup>See, for example, Conesa and Krueger (1999), De Nardi et al. (1999), Kotlikoff et al. (1999), Altig et al. (2001), Kotlikoff et al. (2007), Nishiyama and Smetters (2007) and Attanasio et al. (2007).

economy and the calibration of the model is discussed in Section 3. Section 4 presents the quantitative findings of the paper. Section 5 concludes.

## 2 Model

This section describes the details of the economic model and presents individuals' recursive problem and the definition of a stationary equilibrium.

### 2.1 Demographics

The economy is populated by overlapping generations of individuals. Individuals enter the economy at age  $j_0$  and face lifespan uncertainty. The conditional probability of survival from age  $j$  to age  $j + 1$  is denoted as  $s_j$ . The maximum possible age is  $j = J$ , with  $s_J = 0$ . The size of new cohort grows at a constant rate  $n$ . Individuals derive utility from leaving bequest at death, denoted as  $u_B(b)$  for the amount of assets left  $b$  at death. Bequests are assumed to be collected and distributed as a lump-sum transfer to the entire population. Individuals enter the economy with no assets except for the transfer of the lump-sum bequests.

### 2.2 Endowments

Each individual can allocate one unit of disposable time to leisure or market work. Individuals' earnings are given by  $y_L = \tilde{\omega}h$ , where  $\tilde{\omega}$  denotes the wage rate per work hour  $h$  of each individual and is determined as

$$\tilde{\omega} = \omega(j, h)\eta w.$$

$\omega(j, h)$  is the part of the wage that depends on the age and work hours of each individual and  $\eta$  denotes an idiosyncratic labor productivity that evolves stochastically.  $w$  is the wage rate determined in the market as discussed in section 2.4.

### 2.3 Preferences

Individuals order the sequence of consumption and labor supply over the life-cycle according to a time-separable utility function

$$E \left\{ \sum_{j=j_0}^J \beta^{j-j_0} u(c_j, h_j) \right\},$$

where  $\beta$  is the subjective discount factor and the expectation is with respect to the shocks associated with the time of death and idiosyncratic labor productivity. Consumption and labor supply at age  $j$  are denoted as  $c_j$  and  $h_j$ , respectively.

## 2.4 Technology

Firms are competitive and produce output according to a constant returns to scale technology of the form  $Y = F(K, L) = K^\alpha(AL)^{1-\alpha}$ , where  $K$  and  $L$  are aggregate capital and labor inputs and  $\alpha$  is capital's share of output.  $A$  is the total factor productivity which we assume is constant. Capital depreciates at a constant rate  $\delta \in (0, 1)$ . The firm rents capital and hires labor from individuals in competitive markets, where factor prices  $r$  and  $w$  are equated to the marginal productivities as  $r = F_K - \delta$  and  $w = F_L$ .

## 2.5 Social security

The government in the benchmark economy operates a pay-as-you-go pension system similar to the current U.S. system. A proportional tax  $\tau^s$  is imposed on earnings of working individuals up to the maximum amount of  $y^s$ , above which the social security tax phases out to zero. Once reaching the normal retirement age  $j_R$  each retired agent starts to receive benefits  $ss$ . The amount of the benefits is determined as a concave function of an individual's average lifetime earnings. We will consider reforms of the social security system in section 4.

## 2.6 Fiscal policy

The government spends an exogenous amount of  $G$  on public purchases of goods and services and issues one-period riskless debt  $D'$ , which pays the interest rate of  $r$ . Besides social security taxes, revenues are raised from taxation on labor income, capital income and consumption at proportional rates denoted as  $\tau^l$ ,  $\tau^k$  and  $\tau^c$ . The labor income tax  $\tau^l$  is determined in equilibrium so that the following consolidated government budget constraint is satisfied every period.

$$G + (1 + r)D + \sum_x ss(x)\mu(x) = \sum_x [\tau^l \tilde{w}h(x) + \tau^s \min\{\tilde{w}h(x), y^s\} + \tau^k r(a(x) + b) + \tau^c c(x)] \mu(x) + D', \quad (1)$$

where  $\mu(x)$  denotes the measure of individuals in individual state  $x$ ,  $D$  is the debt issued in the previous period and  $D'$  is the proceeds of the debt issued in the current period.<sup>3</sup>

## 2.7 Market structure

The markets are incomplete and there are no state contingent assets to insure against the idiosyncratic labor income and mortality risks. Individuals can, however, imperfectly self-insure against risks by accumulating one-period riskless assets. Individuals are not allowed to borrow against future income and transfers, i.e.  $a_j \geq 0$  for all  $j$ .

## 2.8 Individuals' problem

The state vector of each individual is given as  $x = \{j, a, \eta, e\}$ , where  $j$  denotes age,  $a$  assets accumulated in the previous period,  $\eta$  the idiosyncratic labor productivity, and  $e$  the index of cumulated labor earnings that determine the social security benefit. Given the states, each individual optimally chooses consumption, saving and labor supply.

The problem is solved recursively and the value function  $V(x)$  of an individual in state  $x$  is given as follows.

$$V(j, a, \eta, e) = \max_{c, h, a'} \{u(c, h) + \beta s_j E[V(j+1, a', \eta', e')] + (1 - s_j)u_B(a')\}$$

subject to

$$\begin{aligned} c + a' &= (1 + r)(a + b) + \tilde{\omega}h + ss(x) - T(x), \\ a' &\geq 0, \\ e' &= e, \text{ for } j \geq j_R, \end{aligned}$$

where  $T(x)$  denotes the taxes paid by an individual in state  $x$ .

$$T(x) = \tau^c c + \tau^k r(a + b) + \tau^l \tilde{\omega}h + \tau^s \min\{\tilde{\omega}h, y^s\}$$

The state  $e$  that represents cumulated labor earnings evolves according to the sequence of realized labor productivity shocks and endogenously chosen work hours.

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<sup>3</sup>In stationary equilibrium, all aggregate variables grow at a constant rate  $n$  and  $D' = (1 + n)D$ .

## 2.9 Stationary competitive equilibrium

For a given set of exogenous demographic parameters  $\{s_j\}_{j=1}^J$  and  $\{n\}$  and government policy variables  $\{G, D', ss, \tau^s, \tau^k, \tau^c\}$ , a stationary competitive equilibrium consists of agents' decision rules  $\{c(x), h(x), a(x)\}$  for each state  $x$ , factor prices  $\{w, r\}$ , labor income tax rate  $\{\tau^l\}$ , a lump-sum transfer of accidental bequests  $\{b\}$  and the measure of individuals  $\{\mu(x)\}$  that satisfy the following conditions:

1. Individuals' allocation rules solve their recursive optimization problems defined in section 2.8.
2. Factor prices are determined competitively.
3. The lump-sum bequest transfer is equal to the amount of assets left by the deceased.

$$b = \sum_x a(x)(1 - s_{j-1})\mu(x). \quad (2)$$

4. The labor and capital markets clear.

$$L = \sum_x \omega(j, h)\eta h(x)\mu(x), \quad (3)$$

$$K = \sum_x (a(x) + b)\mu(x) - D. \quad (4)$$

5. The labor income tax satisfies the government budget constraint defined in equation (1).
6. The goods market clears.

$$\sum_x c(x)\mu(x) + K' + G = Y + (1 - \delta)K. \quad (5)$$

7. The distribution of individuals across states is stationary.  $\mu(x) = R_\mu[\mu(x)]$ , where  $R_\mu$  is a one-period transition operator on the distribution.

## 3 Calibration

This section presents the parametrization of the model. The model period corresponds to a year. The unit of the agents in the model is an individual. For the

data that is used to derive the target moments of calibration, we use male and female individual data except for the asset data as we discuss below. More details about the sample selection for each moment are discussed below. The parameters are summarized in Table 1.<sup>4</sup>

### 3.1 Demographics

The conditional survival rates  $s_j$  are calibrated based on the life-tables of Bell and Miller (2005). We use the estimates for the age-dependent survival rates of 2010 and take the average of the male and female figures. The growth rate  $n$  of the new entrants is set at 1.2%, the long-run average in the U.S. We assume that 20% of “new-borns” enter the labor force at each age between 20 and 24 every period. Individuals live up to the maximum age of 100 ( $J = 81$ ).

When we simulate the economy under alternative demographics (which we call an “economy with aging”) in section 4, we use the projected survival rates of 2100 from Bell and Miller (2005) and the growth rate of 0.5%, based on the projections of the U.S. Census Bureau.<sup>5</sup> Figure 1 shows the unconditional survival rates for both economies.

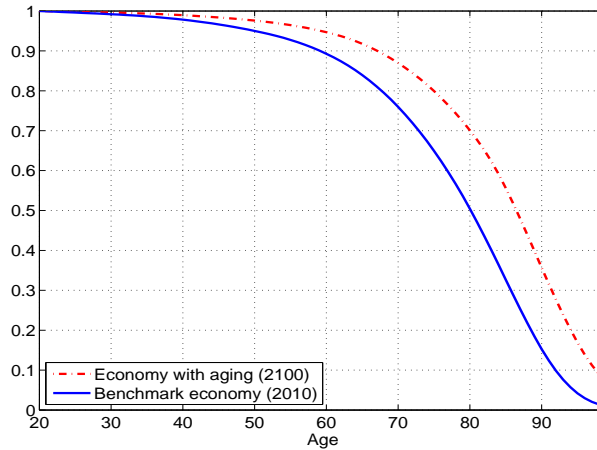


Figure 1: Survival rates (unconditional): For each age  $j$ , the unconditional survival rates are computed as  $\prod_{i=1}^j s_{i-1}$  with  $s_0 = 1.0$ .

<sup>4</sup>The dollar amounts in the calibration are normalized in terms of the average earnings based on the average earnings of workers in our PSID samples (\$48,000 in 2006 dollars or \$52,000 in 2010 dollars). Outcomes of the model in various figures in section 4 are expressed in 2010 dollars.

<sup>5</sup><http://www.census.gov/population/www/projections/natdet-D1A.html>



### 3.2 Endowments, preferences, and technology

To obtain the life-cycle profile of labor market variables such as labor force participation, work hours and wage rates, we use the Panel Study of Income Dynamics (PSID) and its individual data for male and female heads of households.

**Endowments:** The idiosyncratic component  $\eta$  of a worker's wage is specified as a first-order autoregressive process in log with a persistence parameter  $\rho = 0.97$  and the variance of the white noise  $\sigma^2 = 0.02$ , which lie in the range of estimates in the literature (see, for example, Heathcote, et al, 2010). We approximate this continuous process with a five-state, first-order discrete Markov process.

The component  $\omega(j, h)$  is a function of age and hours worked given as

$$\ln \omega(j, h) = \xi \ln h + \psi_j.$$

The coefficient  $\xi$  represents the part-time wage penalty and the value is set at 0.415, which implies that individuals who work 1000 hours per year earn 25% less per hour than those who work 2000 hours per year, as estimated by Aaronson and French (2004). We use work hour and wage data in the PSID data in 2007 to derive the age-specific profile of  $\psi_j$  as a residual wage net of the hours effect,  $\{\ln \omega(j, h) - \xi \ln h\}$ , using the life-cycle profile of average work hours.

Figure 2 shows the profile of age-dependent productivity  $\psi_j$ .

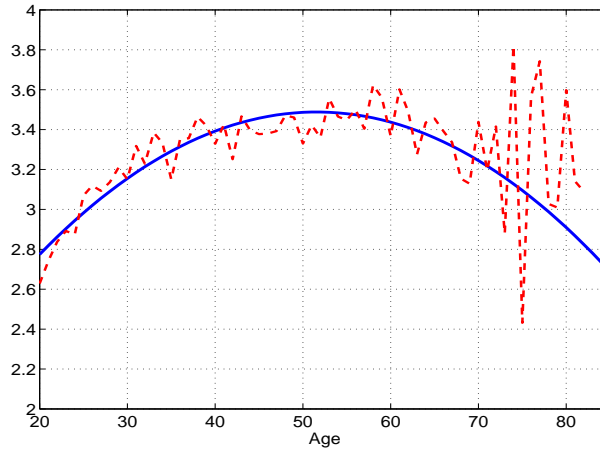


Figure 2: Age-dependent labor productivity  $\psi_j$ : The dashed curve represents the log wage net of the hours effect from the PSID data and the solid line represents a fitted line using a polynomial.

**Preferences:** The instantaneous utility function takes the following specification.

$$u(c, h) = \frac{c^{1-\sigma}}{1-\sigma} + \chi \frac{(1-h-\theta_j \cdot i_p)^{1-\gamma}}{1-\gamma} \quad (6)$$

The parameter  $\chi$  represents the weight on utility from leisure relative to consumption.  $i_p$  is an indicator that takes a value 0 when  $h = 0$  and 1 otherwise.  $\theta_j$  represents the disutility associated with the participation in the labor market. We assume that the fixed cost of participation is measured in terms of lost time for leisure and varies by age.

Figure 3 shows the life-cycle profile of labor force participation rate in the PSID data, in which we define participation as working at least 300 hours in a given year.

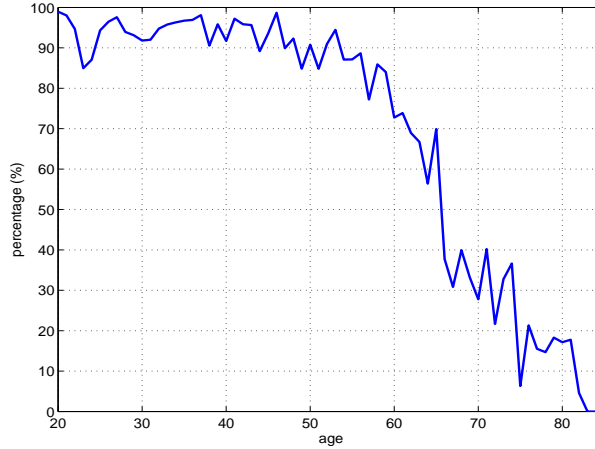


Figure 3: Life-cycle profile of labor force participation rate: data

Until individuals reach mid-50s, the profile is flat and a great majority of individuals participate in the labor force. The participation rate declines to about 70% by age 60 and falls sharply thereafter, reaching almost 0% in early-80s. Conditional on surviving, individuals who enter the labor market at age 20 spend about 44 years of their life participating in the labor market. We assume the functional form of  $\theta_j = \kappa_1 + \kappa_2 j^{\kappa_3}$  for the age-dependent fixed cost of participation and calibrate the three parameters of the function to match these three targets, average participation rate at age 60 and in early 80s, and average work years over the life-cycle.<sup>6</sup> The

<sup>6</sup>For normalization, the age  $j$  in the formula is expressed as the years since age 20 as a fraction of workable years, that is, 66 years.

profile of the participation cost  $\theta_j$  is shown in Figure 4.

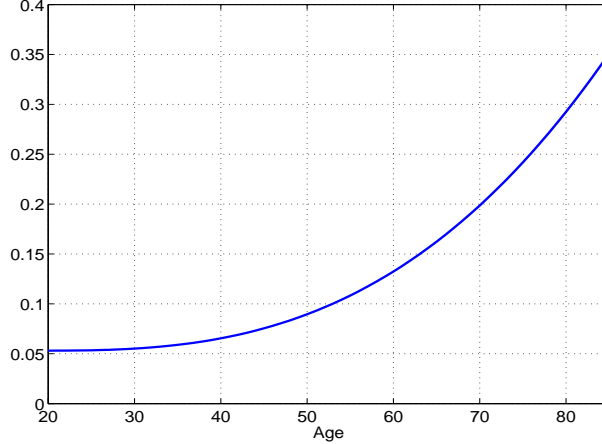


Figure 4: Fixed cost of participation by age  $\theta_j$

We assume that individuals make the participation decision between the ages of 20 and 85 and everyone withdraws from the labor market at 86 permanently.

The utility from bequest is assumed to be linear as in Kopczuk and Lupton (2007) and defined as  $u_B(b) = \phi_B b$ . The coefficient  $\phi_B$  determines the relative weight on the bequest utility. According to the SCF, the ratio of the average wealth held by households above age 65 to those between age 20 and 64 is 1.5. Studies find many elderly keep large amounts of assets until very late in life. According to the SCF, households at age 65 and beyond hold 50% more assets than younger households of age 20-64 on average and we calibrate the value of  $\phi_B$  to match the ratio.<sup>7</sup>

The subjective discount factor  $\beta$  is set so that the model has a capital-output ratio of 3.0 in the initial steady state.<sup>8</sup> The parameter  $\chi$  is chosen so that the average work hours of working individuals equal to 38% of disposable time as in the PSID data. Figure 5 shows the hours profile over the life-cycle from the PSID samples.<sup>9</sup>

<sup>7</sup>Ideally we would like to have the profile of wealth for individuals in a household, to be consistent with the calibration of other variables. Given the difficulty in distinguishing assets of spouses and individuals in a household, we assume that the life-cycle profile of households wealth approximates that of individuals and use the household data.

<sup>8</sup>The capital stock is assumed to consist of private fixed capital, government capital and the stock of durables. Imputed income flows from the last two components of capital stock are added to measured GNP so that the measurements are consistent.

<sup>9</sup>The hours are expressed as a fraction of disposable time, based on 15 hours per day times 365

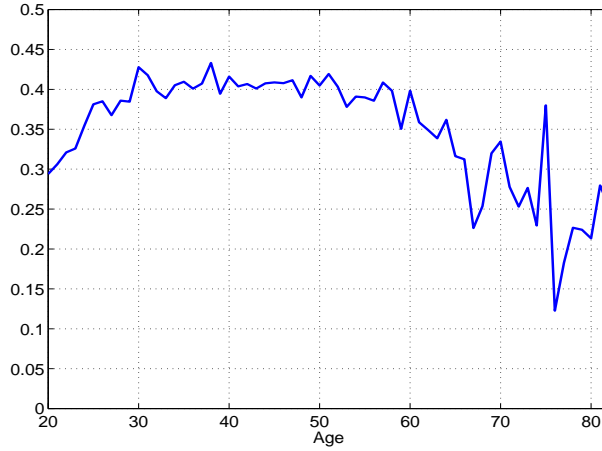


Figure 5: Work hours over the life-cycle: data

We set the risk-aversion parameter  $\sigma$  at 2. The parameter  $\gamma$  is set at 4.0, which implies the intertemporal labor supply elasticity of about 0.32 on average, in line with the estimates using the micro data, as surveyed in Browning, Hansen, and Heckman (1999).<sup>10</sup>

**Technology:** The income share of capital  $\alpha$  is set at 0.40, based on private and public fixed capital including the stock of durables. The depreciation rate  $\delta$  is  $0.082 = \frac{X/Y}{K/Y} - n$ , which is implied by the equilibrium law of motion for the capital in the steady state, where we target an investment-output ratio  $X/Y$  of 0.28 and a capital-output ratio  $K/Y$  of 3.0.<sup>11</sup> The TFP parameter  $A$  is set to normalize the unit of the model and to achieve the average earnings is 1.0 in the model's equilibrium.

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days.

<sup>10</sup>Note that the actual elasticity depends on the age and work hours of each individual. The average elasticity is computed based on the average work hours of 0.38 and the average participation cost of 0.13,  $(1/\gamma) * (1 - 0.38 - 0.13)/0.38$  with  $\gamma = 4$ . The elasticity is higher for individuals who work less and are older.

<sup>11</sup>Note that we abstract from technological growth since we also consider preference specifications that are not consistent with a balanced growth path. This allows us to implement utility functions with alternative values of the coefficient of relative aversion and labor supply elasticity separately that are considered in the literature.

### 3.3 Government

**Social security:** In the benchmark economy, the government runs a pay-as-you-go social security program that captures the features of the system in the U.S. We set the social security tax rate  $\tau^s$  at 10.6% with the maximum taxable amount of  $y^s = \$106,800$  as it is in the U.S. in 2009-11. The benefit, or the Primary Insurance Amount (“PIA”), is determined as a concave piecewise linear function of the career-average earnings (“AIME”), which we capture through the state variable  $e$ . In 2010, the marginal replacement rate is 90% for the average earnings up to \$9,132, above which the replacement rate falls to 32%. For earnings above \$55,032, the replacement rate is 15%.<sup>12</sup> See Appendix A for more details about the computation of the AIME and PIA.

The social security’s replacement rate, defined as the ratio of the average benefits to the average earnings of workers, is 40% in the benchmark model.

**Government expenditures, public debt and taxes:** In the benchmark economy, we set the government spending  $G$  at 20% of output, which is the average ratio of government consumption expenditures and investment to GDP in the post-war period. The ratio of federal debt held by the public to GDP is set at 40%. We assume a consumption tax rate of 5% and a capital income tax rate of 30%. The labor income tax is set so that the overall government budget constraint is satisfied.

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<sup>12</sup>The bend points for the PIA formula are adjusted every year. The maximum monthly benefit is determined as the PIA that corresponds to the maximum taxable earnings.

Table 1: Parameters of the model

Parameter	Description	Values/source
<i>Demographics</i>		
$n$	population growth rate	1.2%
$\{s_j\}_{j=1}^J$	conditional survival probabilities	Bell and Miller (2005)
$J$	maximum age	81 (100 years old)
<i>Preference</i>		
$\beta$	subjective discount factor	0.9815
$\chi$	weight on leisure	0.5123
$\gamma$	leisure utility curvature	4.0
$\{\kappa_i\}_{i=1}^3$	cost of labor force participation	{0.0531, 0.298, 2.780}
$\phi_B$	weight on bequest utility	0.4386
<i>Labor productivity process</i>		
$\rho_\eta$	persistence parameter	0.97
$\sigma_\eta^2$	variance	0.02
$\psi_j$	age-dependent productivity	see text
<i>Technology and production</i>		
$\alpha$	capital share of output	0.4
$\delta$	depreciation rate of capital	8.2%
$A$	scale parameter	normalization
<i>Government</i>		
$\tau^k$	capital income tax	30.0%
$\tau^c$	consumption tax rate	5.0%
$\tau^l$	labor income tax rate	22.1%
$G$	government purchases	20% of GDP
$D$	government debt	40% of GDP
$\tau^s$	social security tax rate	10.6%
$j_R$	normal retirement age (benefit eligibility)	47 (66 years old)
$y^s$	social security maximum taxable earnings	\$106,800

## 4 Numerical results

In this section, we will first present the outcome of the benchmark economy, focusing on the life-cycle profile of individual decision variables. We will then simulate the model with the shift in demographics, which is financed by four different policy options and assess the economic effects of alternative policies.

## 4.1 Benchmark economy

Figure 6 shows the labor force participation of individuals along the life-cycle in the benchmark model. As we saw in the calibration section and in Figure 3, in the data the labor force participation lies in the range of 90-100% until mid 50s and the profile is very flat in this age range. Thereafter, the participation starts to decline gradually and then sharply in mid to late 60s, eventually reaching below 20% by age 70 or so. Our model generates this pattern although we do not capture the relatively small fraction of young individuals who do not participate in the labor market, partly because our model is not rich enough to incorporate various possible reasons for non-participation such as time for human capital investment or child-bearing, and unemployment among other factors. The model generates a gradual decline in labor force participation starting in 50s and more sharply in 60s. The pattern of the withdrawal from the labor market in the model is explained by the combination of the rising participation cost, a decline in the labor productivity and wages at mid to old ages and the income effect that is strengthened through the rise in wealth and consumption as they age.

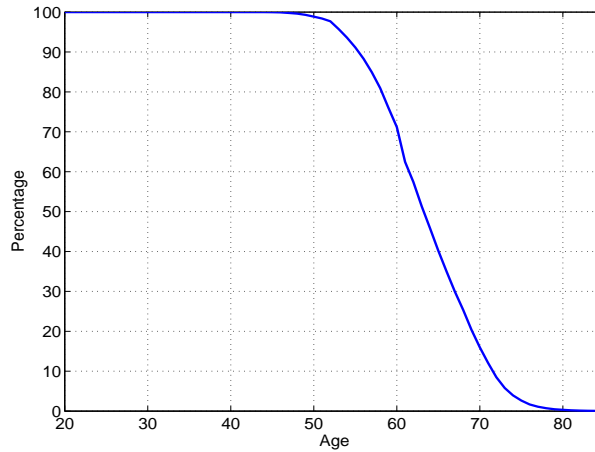


Figure 6: Life-cycle profile of labor force participation rate

Figure 7 shows the profile of work hours in the benchmark model. Hours are fairly flat initially and lies in the range of 0.35 and 0.45 between ages 20 and 50, while trending down as they age. Hours are much lower at very old ages, falling to about one quarter of disposable time by age 70 and continuing to decline thereafter. The overall pattern of hours profile is consistent with the data as shown in Figure 5,

although the model does not capture the mildly hump-shaped profile in the data, in which hours start low in early 20s and rise during the first 10 years. Incorporating the time set aside for human capital investment or short-term or part-time jobs that a relatively large number of younger individuals undertake during the years of ‘job churning’ is likely to improve the fit.

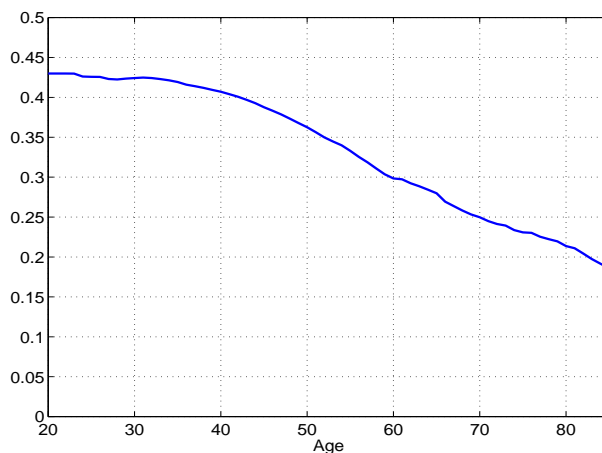


Figure 7: Life-cycle profile of work hours

Figure 8 shows the life-cycle profile of average assets by age. Individuals in the model save and accumulate wealth for three reasons; precautionary savings to insure against idiosyncratic income and mortality risks, retirement savings to supplement consumption after withdrawing from the labor force and savings to leave bequests. The profile exhibits a hump-shape as in the data (see, for example, Gourinchas and Parker, 2002). Individuals start to accumulate wealth at young ages to build a buffer stock of savings to insure against earnings risks and they maintain a significant amount of wealth even at very old ages to insure against the risk of outliving and to leave the optimal amount of bequests.



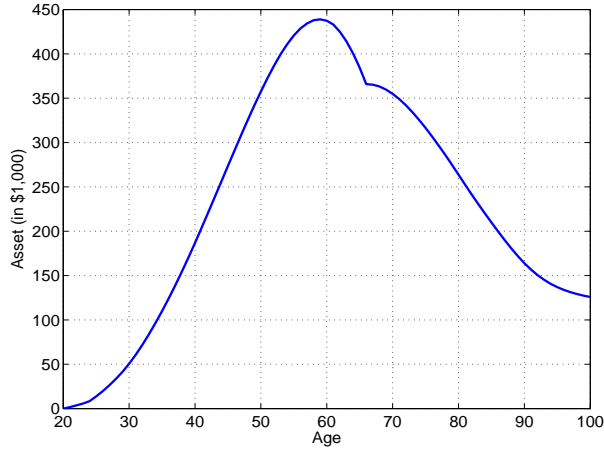


Figure 8: Life-cycle profile of wealth

The social security system currently runs a surplus and the revenues from the payroll taxes exceed the spendings on the benefits. In our benchmark model, the program runs a surplus in the magnitude of 0.44% of GDP every year, corresponding to the current magnitude of the surplus in the U.S. social security system. With the projected shifts in demographics, the spendings will significantly exceed the revenues if there is no reform and the budget gap needs to be financed by some form of taxation in the general budget of the government. If we take a “do-nothing” approach and use the labor income taxes as in the benchmark economy to satisfy the consolidated government budget and finance the increased benefit spending, the deficit of the social security program would amount to 3.3% of the GDP. The labor income tax needs to rise from 22.1% to 28.8%.

When we simulate alternative policy options in the economy with aging in the next section, we assume that the government expenditures are fixed at the level in this economy with “do-nothing” policy. We do so and keep the expenditures the same across experiments in order to control for the level of revenues and isolate the effects of alternative options about social security program from the effects from changes in revenues needed to finance the government spendings.

## 4.2 Policy options

In this section, we study policy options to deal with the change in demographics and balance the budget of the social security program. As mentioned above, we assume

the demographics implied by the projected survival rates and population growth rates for 2100 in this “economy with aging.”<sup>13</sup> The implied old-age dependency ratio, which is defined as the ratio of individuals above age 65 to those at age 20-64, nearly doubles from 23.7% in the benchmark economy to 39.8% in the economy with aging. The life-expectancy at birth implied by the survival rates are 76.8 years and 83.2 years in the two economies, respectively.

In what follows, we study policy options to fill the budget gap associated with the social security and to make the program self-financed. Differently from the benchmark economy, in which we imposed a consolidated budget constraint of equation (1) and backed out the labor tax rate that satisfies it, we assume an independent budget equation for the social security program as in (7) below, separately from the general government budget in (8), which excludes cash flows associated with the social security program. As in the benchmark economy, we adjust  $\tau^l$  to satisfy the general government budget (8).

$$\sum_x ss(x)\mu(x) = \sum_x \tau^s \min\{\tilde{\omega}h(x), y^s\}\mu(x) \quad (7)$$

$$G + (1 + r)D = \sum_x [\tau^l \tilde{\omega}h(x) + \tau^k r(a(x) + b) + \tau^c c(x)] \mu(x) + D' \quad (8)$$

We will consider following four policy options.

- Option 1.** Raise the social security tax.
- Option 2.** Reduce the benefit replacement rates.
- Option 3.** Increase the normal retirement age from 66.
- Option 4.** Means test the benefits.

In each of the policy options, we solve for the value of a policy parameter to make the social security program self-financed and satisfy the program’s budget equation (7) with equality. The parameter will be the payroll tax rate (option 1), the proportional rate for the benefit reduction (option 2), retirement age (option 3), and the level of income where the benefits start to phase out (option 4).

In order to facilitate comparison with the benchmark and across four policy options, we will first focus on the first option and contrast the results with those in

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<sup>13</sup>The survival rates are based on the estimates of Bell and Miller (2005) in 2100 and the population growth rate is based on the growth rate of the number of individuals at age 20 in 2100 according to the Census projections.

the benchmark economy. We will then use the first option as a reference point and compare three other options in terms of deviations in various economic variables from the first option. These steps will help distinguish between the effects of the demographic shift and those of alternative fiscal adjustments.

**Option 1. payroll tax increase:** Table 2 compares the benchmark economy and the first option, in which the demographic shift is financed through an increase in payroll taxes. Since the demographics differ in two economies and the relative size of the population is indeterminate, the changes in aggregate variables (capital, labor, consumption and social security benefit spending) are expressed in terms of changes in per capita levels.

The payroll tax needs to increase by 5.7 percentage points and the total taxes on earnings (sum of labor income tax and payroll tax) rise by 6.7 percentage points, from 32.7% to 39.4%. The tax has to increase significantly to finance the rise in the social security benefits for retirees, which grows by more than 50% compared to the benchmark economy.

Table 2: Benchmark and demographic shift financed by payroll tax increase (Option 1)

	Benchmark	Economy w/ aging Option 1
Capital (per capita)	–	–2.6%
Labor (per capita)	–	–7.5%
Average work hours	–	+1.3%
Consumption (per capita)	–	–3.0%
Wage	–	+2.1%
Interest rate	5.19%	4.79%
Total labor taxes $\tau^y + \tau^s$	32.7%	39.4%
– Labor income tax $\tau^y$	22.1%	23.2%
– Social security tax $\tau^s$	10.6%	16.3%
Social security		
Benefit spending (per capita)	–	+54.1%
Avg replacement rate	39.6%	38.8%
Labor force participation		
Age 20-49	100.0%	100.0%
Age 50-64	81.0%	83.2%
Age 65-85	12.9%	13.0%
Avg work years	44.0	44.7

Despite the increase in labor taxes, individuals work more than in the benchmark economy, both in intensive and extensive margins, in order to supplement the retirement consumption for longer expected periods. The average work hours increase by 1.3% and the average number of years to work rises from 44.0 to 44.7 years. Figure 9 shows the changes in labor force participation rates and average work hours over the life-cycle. Although individuals work more, the average after-tax earnings will decline since the rise in labor supply and wage rate is not large enough to offset the increase in taxes. As a result, disposable income falls and both assets and consumption decline with the demographic shift financed by the tax increase. Capital per capita falls by 2.6% and consumption declines by 3.0%, as shown in Table 2. Note that per-capita labor declines since there will be relatively more old-age individuals that are not in the labor force and the labor supply from a smaller fraction of the

population is used for the production of the economy.<sup>14</sup>

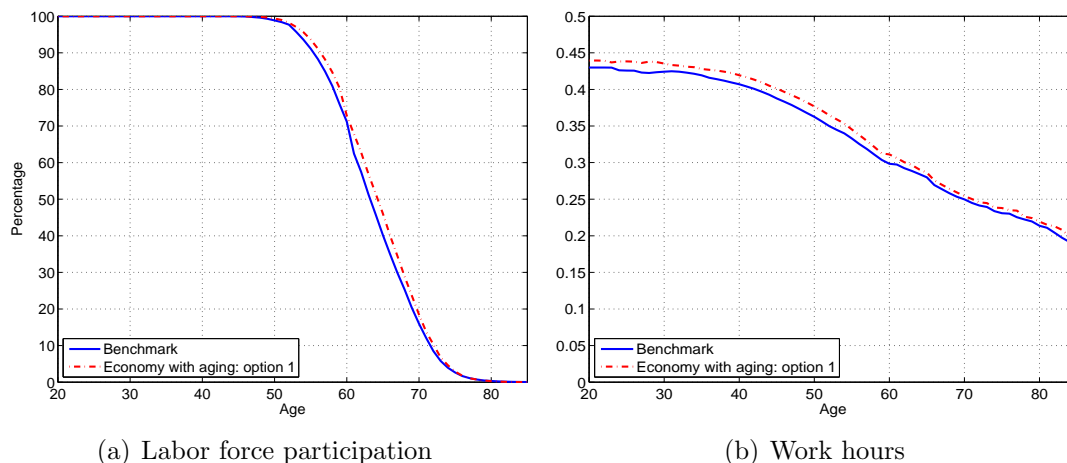


Figure 9: Labor supply in benchmark and option 1

Next we will compare four alternative policies to sustain the social security budget. We use the first option of raising the payroll taxes as a reference point of comparison. The results are summarized in Table 3. Changes are expressed as a deviation from the economy that implements the first policy option.

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<sup>14</sup>If we compute labor per 'working-age' individual of age 20-64, it is higher by 4.9% under option 1 than in the benchmark economy.

Table 3: Comparison of alternative reforms

	Option 1 Tax increase	Option 2 Benefit cut	Option 3 Retire. age	Option 4 Means test
Aggregate variables				
Capital	–	+14.4%	+10.1%	–2.5%
Labor	–	+0.6%	+0.8%	–0.9%
Average work hours	–	–2.4%	–1.5%	+1.7%
Consumption	–	+3.9%	+3.2%	–1.7%
Wage	–	+5.3%	+3.6%	–0.7%
Interest rate	4.8%	3.8%	4.1%	4.9%
Tax rates				
Total labor taxes $\tau^y + \tau^s$	39.4%	32.5%	32.9%	34.2%
– Labor income tax $\tau^y$	23.2%	21.9%	22.3%	23.6%
– Social security tax $\tau^s$	16.3%	10.6%	10.6%	10.6%
Social security				
Benefit spending	–	–31.1%	–31.3%	–35.6%
Avg replacement rate	38.8%	26.3%	38.9%	24.6%
Labor force participation				
Age 20-49	100.0%	100.0%	100.0%	100.0%
Age 50-64	83.2%	88.2%	87.3%	82.2%
Age 65-85	13.0%	19.3%	18.1%	4.5%
Avg work years	44.7	46.8	46.3	43.0

**Option 2. benefit cut:** In option 2, we reduce benefit replacement rates by shifting down the benefit formula proportionally for given level of past earnings  $e$ , that represents past earnings of individuals. The payroll tax rate  $\tau^s$  remains at 10.6% as in the benchmark economy. For the program’s budget to balance, the benefit scale must decline by about one-third (32.4%). The social security’s average replacement rate declines sharply from 38.8% under option 1 to 26.3%.

With lower benefits provided by the government, individuals save and accumulate wealth more aggressively to supplement retirement consumption. The aggregate stock of capital will be 14.4% higher than in option 1. The significant rise in capital will raise the capital-labor ratio and the interest rate declines from 4.8% under

option 1 to 3.8%.

Individuals work longer and the participation rate at age 50-64 and 65-85 will rise by 5.0 and 6.3 percentage points, respectively. The average number of years that individuals work along the life-cycle increases by more than two years, from 44.7 to 46.8 years. Since the age decomposition of workers changes and there are relatively more of old-age individuals, who work fewer hours than the young, the average work hours decline by 2.4%. The aggregate labor supply increases but only by 0.6%. Given the sizeable decline in the interest rate, the consumption and labor supply profiles become flatter. As a result, individuals work relatively more at older ages and the average work hours of younger individuals decline slightly, which contribute to a muted change in the aggregate labor supply.

**Option 3. normal retirement age increase:** In the third option, the normal retirement age is raised to reduce the benefit spendings and balance the budget of the social security. As in option 2, the payroll tax rate remains the same at 10.6%. The retirement age will have to rise by 7 years from 66 to 73 years old to close the budget gap.<sup>15</sup>

As shown in Table 3, effects on aggregate variables are very similar to those under the option 2 studied above, not only qualitatively but also quantitatively. Individuals increase savings for retirement and aggregate capital stock is about 10% higher than in the economy under option 1. As shown in Figure 10, the life-cycle patterns of saving are somewhat different in options 2 and 3. In option 3, individuals start to decumulate wealth more quickly after the peak is reached at around age 60 to finance their consumption, while the pace of decumulation is much slower under option 2. Once individuals reach the retirement age of 73, they are entitled to higher benefits than in option 2 (note the replacement rate of 38.9% vs 26.3%) and the assets will decline more slowly.

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<sup>15</sup>The exact budget balance of the social security program is a small deficit that corresponds to 0.05% of the GDP, since we assume the retirement age to be in integers. This small deficit is covered by the general government budget through the adjustment of labor income taxes.

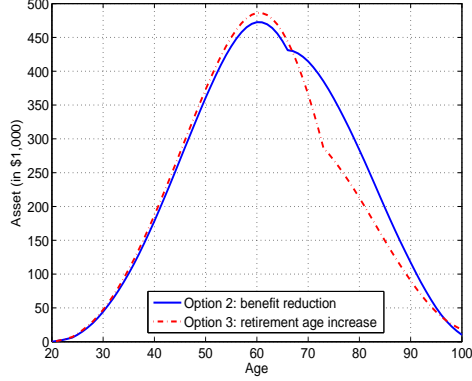


Figure 10: Assets over the life-cycle in options 2 and 3

**Option 4. means-tested benefits:** Lastly, we introduce means test in the determination of the social security benefits. This option appears to be less commonly debated than the previous three options. Many countries including Australia, Denmark and France have at least a component of the social security system that are means-tested. Australia is a notable example, in which the basic pension “Age Pension” is subject to both asset and income test.<sup>16</sup> We assume a simple form of means testing and let the benefits fall one-to-one with income above a threshold level.

Denote by  $\bar{ss}$  the social security benefits without the means test, and the actual benefit after the test would be

$$ss = \max\{\bar{ss} - \max(y - \bar{y}, 0), 0\},$$

where  $y$  is the total income of each individual.  $\bar{y}$  is the cutoff level of income above which the benefits decline one-to-one until they reach zero and it is the policy parameter that is determined so that the social security program is self-financed. The max operator inside the bracket guarantees that the benefits do not exceed the upper limit of  $\bar{ss}$ . The value of  $\bar{y}$  that makes the social security budget in equation (7) holds with equality is almost zero,  $-0.0063$  in model units (or  $-\$330$ ). To illustrate the benefit adjustment by the means test, Figure 11 shows the benefit as a function of total income, for two types of individuals with different past earnings and maximum benefit entitlement  $\bar{ss}$  of  $\$15,000$  and  $\$10,000$ . When the income exceeds

<sup>16</sup>[http://www.centrelink.gov.au/internet/internet.nsf/payments/age\\_pension.htm](http://www.centrelink.gov.au/internet/internet.nsf/payments/age_pension.htm) provides details about the Age Pension.



certain levels (slightly less than \$15,000 and \$10,000, respectively), the benefits will be completely exhausted through the means test. The benefits will vary with income of each individual in a given year.

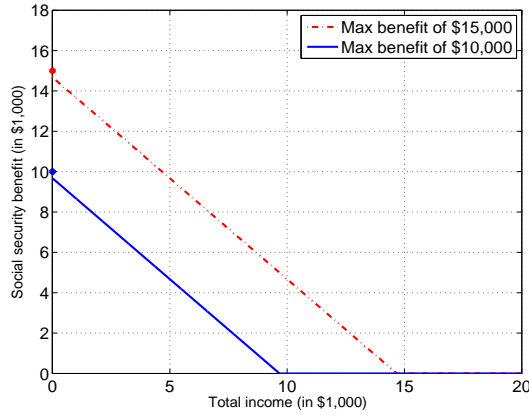


Figure 11: Means-tested social security benefit under option 4: examples

As shown in the last column of Table 3, means-testing the social security benefits will reduce both the savings and labor supply, a result that is in stark contrast from options 2 and 3, although all of the three options aim to control the spending side of the equation through different ways to cut down the benefits. In particular, the labor participation of older individuals will decline significantly under the means test. The participation rates for individuals of ages 50-64 and 65-85 are 82.2% and 4.5% respectively, 1.0 and 8.5 percentage points lower than in option 1. The participation rates are significantly lower than under the previous two options, which gave individuals strong incentives to work longer to supplement retirement consumption. The average work years is 43.0 years, more than 3 years shorter than in options 2 and 3. Figure 12 shows the life-cycle profile of labor supply in options 1 and 4, which exhibits strong disincentives on participation from the means-testing once individuals reach the retirement age of 66. The small number of individuals who remain in the labor force are the ones with very high productivity and they work longer hours to exploit the high wage, with most of them making earnings well beyond the point where the social security benefits are exhausted due to the means-test. Assets decline more sharply as well since the test is on the total income including returns from savings.

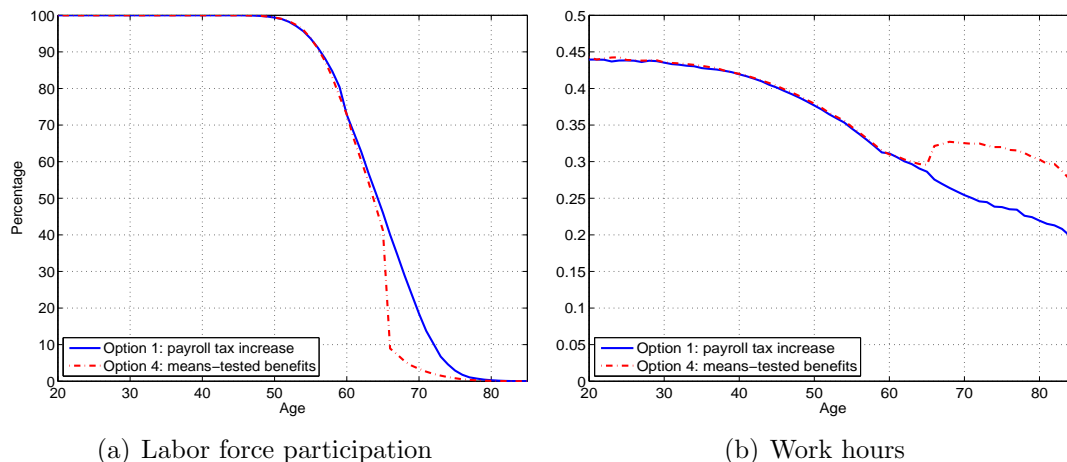


Figure 12: Labor supply over the life-cycle in options 1 and 4

## 5 Conclusion

The social security is not sustainable as it is. The Trust Funds will start to decline soon and be exhausted eventually. The solution is to restore the balance, either by reducing benefits or by raising taxes. The question is what the options are, how big the adjustment has to be under each option, and what the economic consequences are.

We present four policy options to make the social security self-financed and sustainable in light of the coming demographic aging. The options are motivated by recent policy debate and some experience of other countries. We show that the program’s budget will balance each year if we take one of the four options; (1) raise the social security tax by 6 percentage points, (2) reduce the benefit replacement rates by one-third, (3) increase the normal retirement age from 66 to 73, or (4) make the system means-tested and benefits decline one-to-one with income. Although all of these options achieve the same goal of balancing the social security budget, economic consequences differ significantly across them.

We developed a rich model that approximates key macro and micro features of the U.S. economy, in which individuals make life-cycle decisions of consumption, saving and labor supply in both intensive and extensive margins in a competitive production economy. In particular, the model allows endogenous timing of withdrawing from the labor market and we have shown that options have very different effects on labor force participation and retirement decisions of individuals. The pa-

per suggests that fiscal policy can have significant effects on the pattern of individual labor supply over the life-cycle.

Although our model captures key dimensions of heterogeneity across individuals in age, financial and social security wealth and labor productivity, we abstract from other dimensions of potential interest such as unemployment, health status or other sources of expenditures. There are public programs other than social security that pose similar or possibly greater sustainability risks such as Medicaid and Medicare. It would be interesting to extend the study to explore these issues in future research.

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## A Social security benefit formula

Social security benefits are determined as a concave piece-wise linear function of the Average Indexed Monthly Earnings (“AIME”). The AIME measures the worker’s career-average earnings and it is computed as the average of a beneficiary’s 35 highest annual earnings.<sup>17</sup>

In the model, we are not able to keep track of the entire history of earnings due to the limitation in the computation capacity. To approximate the AIME formula, we take the following strategy, which follows French (2005). The state variable  $e$  summarizes the average earnings and approximate the role of the AIME. We assume that during the first 35 years after individuals enter the economy, the state variable  $e$  is updated recursively as

$$e_{t+1} = e_t + \frac{y_{L,t}}{35}$$

where  $y_L$  is the covered earnings, that is,  $y_L = \min\{\tilde{\omega}h, y^s\}$ . Since we cannot store the information of 35 highest earnings for each individual in the computation, we assume that after 35 years the state is updated only if the new earnings exceed the current state of  $e_t$ ;

$$e_{t+1} = e_t + \max\left\{0, \frac{y_{L,t} - e_t}{35}\right\}.$$

The Primary Insurance Amount (“PIA”) is based on the AIME as

$$PIA_t = \begin{cases} 0.9 \times AIME_t & \text{if } AIME_t \leq \$9,132 \\ \$8,219 + 0.32 \times (AIME_t - \$9,132) & \text{if } \$9,132 < AIME_t \leq \$55,032 \\ \$22,907 + 0.15 \times (AIME_t - \$55,032) & \text{if } AIME_t > \$55,032 \end{cases}$$

The social security benefit  $ss$  in the model corresponds to the  $PIA$  and determined as a function of the state variable  $e$ , which corresponds to  $AIME$  in the above formula.

## B Computation note

We summarize the steps to compute the stationary equilibrium of the model.

**Step 1:** Guess a set of equilibrium variables, which consist of aggregate capital  $K$ , labor supply  $L$ , labor income tax  $\tau^l$  and bequest  $b$ .

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<sup>17</sup>The AIME considers earnings only up to the maximum earnings cap, which is \$106,800 in 2009-11.

- Step 2:** Solve individuals' problems and derive policy functions at each state.
- Step 3:** Compute the distribution of individuals across states.
- Step 4:** Compute aggregate moments implied by the distribution and verify if equilibrium conditions are satisfied. If not, update guesses for the equilibrium variables and return to step 2.