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Abstract

The current U.S. Social Security program redistributes resources from high wage workers to low wage workers and from two-earner couples to one-earner couples. The present paper extends a standard general-equilibrium overlapping-generations model with uninsurable wage shocks to analyze the effect of spousal and survivors benefits on the labor supply of married couples. The heterogeneous-agent model calibrated to the 2009 U.S. economy predicts that removing spousal and survivors benefits would increase female market work hours by 4.3-4.9% and total output by 1.1-1.5% in the long run, depending on the government financing assumption. If the increased tax revenue due to higher economic activity after the policy change was redistributed in a lump-sum manner, a phased-in cohort-by-cohort removal of these benefits would make all current and future age cohorts on average better off.

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1 Introduction

The current Old-Age and Survivors Insurance (OASI) program of the U.S. Social Security system redistributes resources from high wage workers to low wage workers and from two-earner couples to one-earner couples. Due to computational difficulty, however, most previous literature on the dynamic general-equilibrium analyses of Social Security does not explicitly consider the redistribution between one-earner and two-earner households.¹ The lack of spousal and survivors benefits in the model economy potentially underestimates the labor supply distortion of the OASI payroll tax. In an economy with these benefits, the secondary earners consider a larger portion of their payroll tax payments to be labor income taxes rather than pension contributions, and the after-tax wage elasticity of the secondary earners' labor supply is in general much higher.

The present paper extends a standard dynamic general equilibrium overlapping-generations (OLG) model with heterogeneous households and incomplete markets by implementing the joint labor supply decision of married couples; calibrates the model to the 2009 U.S. economy with spousal and survivors benefits; and analyzes to what extent the current spousal and survivors benefits possibly distort the labor supply decision of married households and whether the government can improve the social welfare without significantly reducing the insurance aspect of the current Social Security OASI program.

In the model economy, households are heterogeneous with respect to their marital status (married, widowed, or widowed), age, wealth, husband's market wage rate, wife's market wage rate, the husband's average historical earnings, and the wife's average historical earnings. In each period, which is a year, a working-age household receives idiosyncratic market wage shocks (one for the husband and another for the wife) and jointly chooses the optimal consumption, market work hours, and end-of-period wealth to maximize their rest of the lifetime utility, taking factor prices and government policy schedule as given.

The present paper first constructs a baseline economy, which is on the balanced growth path,

¹For example, Auerbach and Kotlikoff (1987), İmrohoroglu, İmrohoroglu, and Joines (1995), Kotlikoff, Smetters, and Walliser (1999), Conesa and Krueger (1999), Nishiyama and Smetters (2007), and Huggett and Para (2010).

with the current OASI system with spousal and survivors benefits, and it checks whether the model economy matches the U.S. economy in terms of the shares of elderly women by type of OASI benefits—worker’s own benefits, spousal benefits, and survivors benefits received by widows. Then, it assumes a 40-year cohort-by-cohort gradual removal of spousal and survivors benefits and solves the model for a steady-state equilibrium and an equilibrium transition path under several different government financing assumptions. Regarding the OASI budget, the paper assumes that it is separated from the rest of the government budget and that workers’ own benefits are increased proportionally by keeping the payroll tax rate at the same level.

The main findings of the present paper are as follows: By removing spousal and survivors benefits from the current OASI system, the market work hours of women would increase by 4.3-4.9% in the long run, depending on the government financing assumption: increasing government consumption (waste), increasing lump-sum transfers, or cutting marginal income tax rates. The market work hours of men would increase only by 0.0-0.4%. Total labor supply in efficiency units would increase by 0.8-1.1% and total output (GDP) would also increase by 1.1-1.5% in the long run. The macroeconomic effect would be largest if the government cut the marginal income tax rates and smallest if it increased transfer spending instead to balance the budget.

If the increased tax revenue due to the policy change was redistributed to households by increasing lump-sum transfers, the welfare effect of the policy change would be largest. Under this financing assumption, the phased-in removal of spousal and survivors benefits would make all current and future age cohorts on average better off. If the increased tax revenue was reimbursed by cutting marginal income tax rates, however, young households at the time of policy change and households in the near future would be worse off slightly. Age 21 newborn households would be better off on average by 0.3-0.8% in the long run with the consumption equivalence measure.

To the best of my knowledge, few papers have analyzed the effect of spousal and survivors benefits on the labor supply of married households, as well as on the macro economy and social welfare, by using a large-scale dynamic general equilibrium OLG model. Kaygusuz (2008) is probably the first and only paper that constructs a heterogeneous-agent deterministic OLG model to

explicitly analyze the effect of spousal benefits. The present paper is different from Kaygusuz's in several aspects: it assumes uninsurable idiosyncratic wage shocks in the model economy,² analyzes both spousal and survivors benefits,³ and solves the model for an equilibrium transition path to check if the removal of these benefits are welfare improving even in the short run.

Hong and Ríos-Rull (2007) also construct a heterogeneous-agent OLG model of married and single households to analyze the welfare effect of Social Security in the presence/absence of life insurance and annuity markets. In their model, however, the household's labor supply is inelastic, the age-earning profiles of the workers are deterministic, and Social Security benefits are uniform and independent of the household's earning histories.⁴ The contribution of the present paper is showing how married couples react to a future Social Security benefit schedule by choosing their optimal labor supply as well as saving.

The present paper is also related to papers on female labor supply. Olivetti (2006) constructs a life cycle model of married couples that includes the home production of childcare and learning-by-doing type human capital accumulation, and she analyzes the importance of these on the increase in women's market work hours. Attanasio, Low, and Sánchez-Marcos (2008) also construct a life cycle model of female labor participation (male labor supply is assumed to be inelastic). They explain the change in female labor supply by the declining cost of raising children and labor participation. They assume the earnings of the husband and wife are subject to positively correlated permanent shocks. In the present paper, the model assumes unitary households—perfectly altruistic married couples—similar to the above papers. It abstracts from the home production and human capital accumulation but focuses more on the household's reaction to the current OASI policy.

The rest of the paper is laid out as follows: Section 2 describes the heterogeneous-agent OLG model with the joint decision-making of married couples, Section 3 shows the calibration of the

²If a husband and a wife are not certain about their future market wages, thus their own social security benefits, a possible labor supply distortion caused by the spousal and survivors benefits will be attenuated especially when they are young.

³According to the policy experiments in Section 4, the labor supply and macroeconomic effects of survivors benefits is much larger than that of spousal benefits in the model economy.

⁴Their model assumes that a married couple receives 150% of the average male benefit and that a widow receives 100% of the average male benefit.

baseline economy to the U.S. economy, Section 4 explains the effects of removing spousal and survivors benefits in the long run and in equilibrium transition paths, Section 5 checks the robustness of the model, and Section 6 concludes the paper. Appendix shows the Kuhn-Tucker conditions and the computational algorithm to solve the household optimization problem.

2 The Model Economy

The economy consists of a large number of overlapping-generations households, a perfectly competitive representative firm with constant-returns-to-scale technology, and a government with a commitment technology.

2.1 The Households

The households are heterogeneous with respect to the age, $i = 1, \dots, I$, beginning-of-period household wealth, $a \in A = [0, a_{\max}]$, the husband's average historical earnings, $b_1 \in B = [0, b_{\max}]$, the wife's average historical earnings, $b_2 \in B$, the husband's earning ability, $e_1 \in E = [0, e_{\max}]$, the wife's earning ability, $e_2 \in E$, and the marital status m : the husband and wife are both alive ($m = 0$), the husband is alive but the wife is deceased ($m = 1$), and the husband is deceased but the wife is alive ($m = 2$).

The model age $i = 1$ corresponds to the real age of 21. For simplicity, the husband and the wife are the same age in the model economy, and they are married when they enter the economy at age $i = 1$ and never get divorced. The average historical earnings are used for the average indexed monthly earnings (AIME) and determine the primary insurance amounts (PIA) of Social Security pension. The earning abilities of the husband and wife follow the first-order Markov process, and are independent of each other and of the mortality shocks.

In each year, t , a household receives earning ability shocks, e_1 and e_2 , and chooses consumption spending, c , the husband's hours of market work, h_1 , the wife's hours of market work, h_2 , and end-of-period wealth, a' , to maximize their expected lifetime utility. The PIA of a married couple is

calculated separately for the husband and the wife. For a married elderly household ($m = 0$), the secondary earner receives either her own old-age benefit or the spousal benefit (50% of her spouse's old-age benefit), whichever is higher. For a widow(er)ed elderly household ($m = 1$ or 2), the survivor receives either her own old-age benefit or the survivors benefit (100% of her spouse's old-age benefit), whichever is higher.

State Variables. Let $\mathbf{s}$ and $\mathbf{S}_t$ be the individual state of a household and the aggregate state of the economy in year t , respectively,

$$\mathbf{s} = (i, a, b_1, b_2, e_1, e_2, m), \quad \mathbf{S}_t = (x(\mathbf{s}), W_{G,t}),$$

where $x(\mathbf{s})$ is the population density function of households and $W_{G,t}$ is the government net wealth at the beginning of year t , and let Ψ_t be the government policy schedule as of year t ,

$$\Psi_t = \{C_{G,s}, tr_{LS,s}, \tau_{I,s}(\cdot), \tau_{P,s}(\cdot), tr_{SS,s}(\cdot), W_{G,s+1}\}_{s=t}^{\infty},$$

where $C_{G,t}$ is government consumption, $tr_{LS,t}$ is a lump sum transfer that includes accidental bequests to each person, $\tau_{I,t}(\cdot)$ is a progressive income tax function, $\tau_{P,t}(\cdot)$ is a Social Security payroll tax function, $tr_{SS,t}(\cdot)$ is a Social Security benefit function, and $W_{G,t+1}$ is government net wealth at the beginning of the next year.

The Optimization Problem. Let $v(\mathbf{s}, \mathbf{S}_t; \Psi_t)$ be the value function of a heterogeneous household at the beginning of year t . Then, the household's optimization problem is

$$(1) \quad v(\mathbf{s}, \mathbf{S}_t; \Psi_t) = \max_{c, h_1, h_2} \left\{ u(c, h_1, h_2; m) + \tilde{\beta} \phi_{m,i} \sum_{m'=0}^2 \int_{E^2} v(\mathbf{s}', \mathbf{S}_{t+1}; \Psi_{t+1}) d\Pi_i(e'_1, e'_2, m' | e_1, e_2, m) \right\}$$

subject to the constraints for the decision variables,

$$(2) \quad c > 0,$$

$$(3) \quad 0 \leq h_1 < 1 \text{ if } m \neq 2, \quad h_1 = 0 \text{ if } m = 2,$$

$$(4) \quad 0 \leq h_2 < 1 \text{ if } m \neq 1, \quad h_2 = 0 \text{ if } m = 1,$$

and the law of motion of the individual state,

$$(5) \quad s' = (i + 1, a', b'_1, b'_2, e'_1, e'_2, m'),$$

$$(6) \quad a' = \frac{1}{1 + \mu} \left[(1 + r_t)a + w_t e_1 h_1 + w_t e_2 h_2 - \tau_{I,t}(r_t a + w_t e_1 h_1 + w_t e_2 h_2; m) \right. \\ \left. - \tau_{P,t}(w_t e_1 h_1, w_t e_2 h_2) + tr_{SS,t}(i, b_1, b_2, m) + (1 + \mathbf{1}_{\{m=0\}})tr_{LS,t} - (c + \kappa w_t h_2) \right] \geq 0,$$

$$(7) \quad b'_1 = \mathbf{1}_{\{i < I_R, m \neq 2\}} \frac{1}{\bar{v}} \left[(i - 1)b_1 + \min(w_t e_1 h_1, \vartheta_{\max}) \right] + \mathbf{1}_{\{i \geq I_R \text{ or } m=2\}} b_1,$$

$$(8) \quad b'_2 = \mathbf{1}_{\{i < I_R, m \neq 1\}} \frac{1}{\bar{v}} \left[(i - 1)b_2 + \min(w_t e_2 h_2, \vartheta_{\max}) \right] + \mathbf{1}_{\{i \geq I_R \text{ or } m=1\}} b_2,$$

where $u(\cdot)$ is the period utility function, $\tilde{\beta}$ is the growth-adjusted time discount factor, $\phi_{m,i}$ is the joint survival probability (the probability that at least one family member survives) at the end of age i , $\Pi_i(e'_1, e'_2, m' | e_1, e_2, m)$ is the transition probability function of exogenous state variables, μ is the long-run productivity growth rate, r_t is the interest rate, w_t is the wage rate per efficiency unit of labor, and $\mathbf{1}_{\{\cdot\}}$ is an indicator function that returns 1 if the condition in $\{\cdot\}$ holds and 0 otherwise. The present paper does not explicitly model home production to avoid additional complexity, but the model considers the cost of reduced home production when women (wives) work outside the home. In the budget constraint, equation (6), $\kappa w_t h_2$ shows an extra cost for women to work outside the home, e.g., the cost of daycare services and the additional expense of dining outs. For simplicity, the productivity at home is assumed to be equal for all women. In the law of motion of b_1 and b_2 , $\vartheta_{\max}$ are the maximum taxable earnings for the OASI program. To describe a balanced growth path by a steady-state equilibrium, individual variables other than working hours are normalized by using the long-run growth rate, $1 + \mu$.

Preference. The household's period utility function depends on the marital status. The utility functions of a widower ($m = 1$) and a widow ($m = 2$) are a combination of Cobb-Douglas and constant relative risk aversion,

$$u(c, h_1, h_2; m = j) = \tilde{u}_j(c, h_j) = \frac{[c^\alpha(1 - h_j)^{1-\alpha}]^{1-\gamma}}{1 - \gamma} \quad \text{for } j = 1, 2,$$

and the utility function of a married couple ($m = 0$) has the following additively separable form,

$$u(c, h_1, h_2; m = 0) = \sum_{j=1}^2 \tilde{u}_j\left(\frac{c}{1 + \lambda}, h_j\right),$$

where $1 - \lambda \in [0, 1]$ is the degree of joint consumption. For example, all of the household consumption, c , is consumed jointly when $\lambda = 0$, and all is consumed separately when $\lambda = 1$.⁵ With this specification, the growth-adjusted time discount factor is calculated as $\tilde{\beta} = \beta(1 + \mu)^{\alpha(1-\gamma)}$ when β is the unadjusted time discount factor.

The State Transition Function. The model assumes that the husband's working ability and the wife's working ability are independent of each other and of the mortality of their spouses. It also assumes that the deaths of the husband and wife are independent of each other. Then, the exogenous state transition probability function is described as

$$\Pi_i(e'_1, e'_2, m' | e_1, e_2, m) = \Pi_{e_1, i}(e'_1 | e_1) \Pi_{e_2, i}(e'_2 | e_2) p_{m, i}(m' | m),$$

where $\Pi_{e_1, i}(\cdot)$ and $\Pi_{e_2, i}(\cdot)$ are transition probability functions of working ability, and

$$p_{m, i}(0 | 0) = \phi_{1, i} \phi_{2, i}, \quad p_{m, i}(1 | 0) = \phi_{1, i}(1 - \phi_{2, i}), \quad p_{m, i}(2 | 0) = (1 - \phi_{1, i}) \phi_{2, i},$$

⁵The share of joint consumption in total household consumption is calculated as $(1 - \lambda)/(1 + \lambda)$. In a general setting, the utility functions of a husband and wife can be defined separately, $u_1(c_1, c_2, h_1, h_2) = \tilde{u}_1(c_1, h_1) + \varphi \tilde{u}_2(c_2, h_2)$ and $u_2(c_2, c_1, h_2, h_1) = \tilde{u}_2(c_2, h_2) + \varphi \tilde{u}_1(c_1, h_1)$, where $\varphi \leq 1$ is the degree of altruism. The present paper assumes that a married couple is perfectly altruistic, $\varphi = 1$, and that their consumption is equal, $c_1 = c_2 = c/(1 + \lambda)$. Then, we get the unitary utility function of a married couple described above. Kotlikoff and Spivak (1981) and Brown and Poterba (2000) discuss the utility function of a married couple with inelastic labor supply.

$$\begin{aligned}
p_{m,i}(0|1) &= 0, & p_{m,i}(1|1) &= \phi_{1,i}, & p_{m,i}(2|1) &= 0, \\
p_{m,i}(0|2) &= 0, & p_{m,i}(1|2) &= 0, & p_{m,i}(2|2) &= \phi_{2,i}.
\end{aligned}$$

The Income Tax Function. Let y be the taxable income of a household, and let d_m be the sum of deductions and exemptions of the household with marital status m , then,

$$y = \max(r_t a + w_t e_1 h_1 + w_t e_2 h_2 - d_m, 0),$$

where $d_0/2 = d_1 = d_2$. The individual income tax function is one of Gouveia and Strauss (1994),

$$\tau_{I,t}(y; m) = \varphi_t \left[y - (y^{-\varphi_{m,1}} + \varphi_{m,2})^{-1/\varphi_{m,1}} \right],$$

where the parameters (progressive tax rates) depend on the marital status: $m = 0$ (married filing jointly) or $m = 1, 2$ (single).

Social Security Pensions. Let $y_1 = w_t e_1 h_1$ and $y_2 = w_t e_2 h_2$ be the earnings of the husband and the wife, and let $\vartheta_{\max}$ be the maximum taxable earnings for the OASI program. Then the OASI payroll tax function is

$$\tau_{P,t}(y_1, y_2) = \bar{\tau}_{P,t} \left[\min(y_1, \vartheta_{\max}) + \min(y_2, \vartheta_{\max}) \right],$$

where $\bar{\tau}_{P,t}$ is a flat OASI tax rate that includes the employer portion of the tax. Let ϑ_1 and ϑ_2 be the thresholds for the 3 replacement rate brackets, 90%, 32%, and 15%, that calculate the primary insurance amount (PIA) from the average historical earnings. Then, the PIA's of the husband and the wife, $\psi(i, b_1)$ and $\psi(i, b_2)$, are

$$\begin{aligned}
\psi(i, b_j) &= \mathbf{1}_{\{i \geq I_R\}} (1 + \mu)^{40-i} \{ 0.90 \min(b_j, \vartheta_1) \\
&\quad + 0.32 \max[\min(b_j, \vartheta_2) - \vartheta_1, 0] + 0.15 \max(b_j - \vartheta_2, 0) \} \quad \text{for } j = 1, 2,
\end{aligned}$$

and the current-law OASI benefit function is

$$tr_{SS,t}(i, b_1, b_2, m) = \begin{cases} \psi_t \max[\psi(i, b_1) + \psi(i, b_2), 1.5 \psi(i, b_1), 1.5 \psi(i, b_2)] & \text{if } m = 0, \\ \psi_t \max[\psi(i, b_1), \psi(i, b_2)] & \text{if } m = 1, 2, \end{cases}$$

where ψ_t is an OASI benefit adjustment factor. The adjustment factor is set at 1.0 in a baseline economy. When both the husband and the wife are alive ($m = 0$), the OASI benefit is $1.5\psi(i, b_1)$ if $\psi(i, b_2) < 0.5\psi(i, b_1)$, it is $1.5\psi(i, b_2)$ if $\psi(i, b_1) < 0.5\psi(i, b_2)$, and it is $\psi(i, b_1) + \psi(i, b_2)$ otherwise. When one of those is deceased ($m = 1, 2$), the OASI benefit is either $\psi(i, b_1)$ or $\psi(i, b_2)$, whichever is the larger one.

Decision Rules. Solving the household's problem for c , h_1 , and h_2 for all possible states, we obtain the household's decision rules, $c(\mathbf{s}, \mathbf{S}_t; \Psi_t)$, $h_1(\mathbf{s}, \mathbf{S}_t; \Psi_t)$, and $h_2(\mathbf{s}, \mathbf{S}_t; \Psi_t)$.⁶ The other decision rules are also obtained as

$$\begin{aligned} a'(\mathbf{s}, \mathbf{S}_t; \Psi_t) &= \frac{1}{1 + \mu} [(1 + r_t)a + w_t e_1 h_1(\mathbf{s}, \mathbf{S}_t; \Psi_t) + w_t e_2 h_2(\mathbf{s}, \mathbf{S}_t; \Psi_t) \\ &\quad - \tau_{I,t}(r_t a + w_t e_1 h_1(\mathbf{s}, \mathbf{S}_t; \Psi_t) + w_t e_2 h_2(\mathbf{s}, \mathbf{S}_t; \Psi_t); m) \\ &\quad - \tau_{P,t}(w_t e_1 h_1(\mathbf{s}, \mathbf{S}_t; \Psi_t), w_t e_2 h_2(\mathbf{s}, \mathbf{S}_t; \Psi_t)) + tr_{SS,t}(i, b_1, b_2, m) \\ &\quad + (1 + \mathbf{1}_{\{m=0\}})tr_{LS,t} - (c(\mathbf{s}, \mathbf{S}_t; \Psi_t) + \kappa w_t h_2(\mathbf{s}, \mathbf{S}_t; \Psi_t))] \geq 0, \\ b'_1(\mathbf{s}, \mathbf{S}_t; \Psi_t) &= \mathbf{1}_{\{i < I_R, m \neq 2\}} \frac{1}{i} [(i-1)b_1 + \min(w_t e_1 h_1(\mathbf{s}, \mathbf{S}_t; \Psi_t), \vartheta_{\max})] + \mathbf{1}_{\{i \geq I_R \text{ or } m=2\}} b_1, \\ b'_2(\mathbf{s}, \mathbf{S}_t; \Psi_t) &= \mathbf{1}_{\{i < I_R, m \neq 1\}} \frac{1}{i} [(i-1)b_2 + \min(w_t e_2 h_2(\mathbf{s}, \mathbf{S}_t; \Psi_t), \vartheta_{\max})] + \mathbf{1}_{\{i \geq I_R \text{ or } m=1\}} b_2. \end{aligned}$$

The Distribution of Households. Let $x_t(\mathbf{s})$ be the growth-adjusted population density of households in period t , and let $X_t(\mathbf{s})$ be the corresponding cumulative distribution function. We assume that households enter the economy as a married couple with no assets and working histories, i.e., $a = b_1 = b_2 = m = 0$, and that the growth-adjusted population of age $i = 1$ households is

⁶We discretize the individual state space and solve the Kuhn-Tucker conditions of the household problem for each state by using a Newton-type nonlinear equation solver (a modified Powell hybrid algorithm). See Appendix for the computational algorithm used to solve the problem.

normalized to unity,

$$\sum_{m=0}^2 \int_{A \times B^2 \times E^2} dX_t(1, a, b_1, b_2, e_1, e_2, m) = \int_{E^2} dX_t(1, 0, 0, 0, e_1, e_2, 0) = 1.$$

Let ν be the time-invariant population growth rate. Then, the law of motion of the growth-adjusted population distribution is

$$\begin{aligned} x_{t+1}(\mathbf{s}') &= \frac{1}{1 + \nu} \sum_{m=0}^2 \int_{A \times B^2 \times E^2} \mathbf{1}_{\{a'=a'(\mathbf{s}, \mathbf{S}_t; \Psi_t), b'_1=b'_1(\mathbf{s}, \mathbf{S}_t; \Psi_t), b'_2=b'_2(\mathbf{s}, \mathbf{S}_t; \Psi_t)\}} \\ &\quad \times \pi_i(e'_1, e'_2, m' | e_1, e_2, m) dX_t(\mathbf{s}), \end{aligned}$$

where $\pi_i(e'_1, e'_2, m' | e_1, e_2, m)$ is the transition probability density function of exogenous state variables.

Aggregation. The growth-adjusted private wealth, $W_{P,t}$; capital stock (national wealth), K_t , in a closed economy; and labor supply in efficiency units, L_t , are

$$\begin{aligned} W_{P,t} &= \sum_{i=1}^I \sum_{m=0}^2 \int_{A \times B^2 \times E^2} a dX_t(\mathbf{s}), \\ K_t &= W_{P,t} + W_{G,t}, \\ L_t &= \sum_{i=1}^{I_R-1} \sum_{m=0}^2 \int_{A \times B^2 \times E^2} (e_1 h_1(\mathbf{s}, \mathbf{S}_t; \Psi_t) + e_2 h_2(\mathbf{s}, \mathbf{S}_t; \Psi_t)) dX_t(\mathbf{s}). \end{aligned}$$

2.2 The Firm

In each period, the representative firm chooses the capital input, $\tilde{K}_t$, and efficiency labor input, $\tilde{L}_t$, to maximize its profit, taking factor prices, r_t and w_t , as given, *i.e.*,

$$(9) \quad \max_{\tilde{K}_t, \tilde{L}_t} F(\tilde{K}_t, \tilde{L}_t) - (r_t + \delta)\tilde{K}_t - w_t\tilde{L}_t,$$

where $F(\cdot)$ is a constant-returns-to-scale production function,

$$F(\tilde{K}_t, \tilde{L}_t) = A\tilde{K}_t^\theta \tilde{L}_t^{1-\theta},$$

with total factor productivity A , and δ is the depreciation rate of capital. The profit maximizing conditions are

$$(10) \quad F_K(\tilde{K}_t, \tilde{L}_t) = r_t + \delta, \quad F_L(\tilde{K}_t, \tilde{L}_t) = w_t,$$

and the factor markets clear when $K_t = \tilde{K}_t$ and $L_t = \tilde{L}_t$.

2.3 The Government

In the model economy, the payroll tax rate is fixed at the same level and the benefits are adjusted proportionately so that the social security budget is always balanced.⁷ The government's OASI payroll tax revenue, $T_{P,t}$, is

$$(11) \quad T_{P,t}(\bar{\tau}_{P,t}) = \sum_{i=1}^{I_R-1} \sum_{m=0}^2 \int_{A \times B^2 \times E^2} \tau_{P,t}(w_t e_1 h_1(\mathbf{s}, \mathbf{S}_t; \Psi_t), w_t e_2 h_2(\mathbf{s}, \mathbf{S}_t; \Psi_t); \bar{\tau}_{P,t}) dX_t(\mathbf{s}),$$

and the OASI benefit expenditure, $TR_{SS,t}$, is

$$(12) \quad TR_{SS,t}(\psi_t) = \sum_{i=I_R}^I \sum_{m=0}^2 \int_{A \times B^2 \times E^2} tr_{SS,t}(i, b_1, b_2, m; \psi_t) dX_t(\mathbf{s}).$$

In the baseline economy, the parameter, ψ_t , of the benefit function set at 1.0 and the OASI residual is calculated as $TR_O = T_{P,t}(\bar{\tau}_{P,t}) - TR_{SS,t}(\psi_t)$. The OASI residual includes the OASI benefits not considered in this model economy and administrative costs. In the policy experiments below, $\bar{\tau}_{P,t}$ and TR_O are kept at the baseline levels, and the benefit parameter, ψ_t , is adjusted so that the OASI budget is balanced, i.e., $TR_{SS,t}(\psi_t) = T_{P,t}(\bar{\tau}_{P,t}) - TR_O$.

⁷If a policy change increases the labor income of working-age households, other things being equal, elderly households will also be better off through the increased social security benefit under this assumption.

The government's income tax revenue is

$$(13) \quad T_{I,t}(\varphi_t) = \sum_{i=1}^I \sum_{m=0}^2 \int_{A \times B^2 \times E^2} \tau_{I,t}(r_t a + w_t e_1 h_1(\mathbf{s}, \mathbf{S}_t; \Psi_t) + w_t e_2 h_2(\mathbf{s}, \mathbf{S}_t; \Psi_t); m, \varphi_t) dX_t(\mathbf{s}),$$

and the aggregate lump-sum transfer expenditure is

$$(14) \quad TR_{LS,t}(tr_{LS,t}) = \sum_{i=1}^I \sum_{m=0}^2 \int_{A \times B^2 \times E^2} (1 + \mathbf{1}_{\{m=0\}}) tr_{LS,t} dX_t(\mathbf{s}).$$

The government collects accidental bequests—remaining wealth held by deceased households—at the end of period t and distributes it in a lump-sum manner in the same period.⁸ The revenue from accidental bequests is

$$(15) \quad BQ_t = \sum_{i=1}^I \sum_{m=0}^2 \int_{A \times B^2 \times E^2} (1 - \phi_{m,i})(1 + \mu) a'(\mathbf{s}, \mathbf{S}_t; \Psi_t) dX_t(\mathbf{s}),$$

where the survival rate of married couple ($m = 0$) is calculated as $\phi_{0,i} = 1 - (1 - \phi_{1,i})(1 - \phi_{2,i})$.

In the baseline economy, we assume $TR_{LS,t} = BQ_t$ and the individual lump-sum transfer is

$$(16) \quad tr_{LS,t} = \left(\sum_{i=1}^I \sum_{m=0}^2 \int_{A \times B^2 \times E^2} (1 + \mathbf{1}_{\{m=0\}}) dX_t(\mathbf{s}) \right)^{-1} BQ_t.$$

The law of motion of the government net wealth is

$$(17) \quad W_{G,t+1} = \frac{1}{(1 + \mu)(1 + \nu)} \left[(1 + r_t)W_{G,t} + T_{I,t}(\varphi_t) + BQ_t - C_{G,t} - TR_{LS,t}(tr_{LS,t}) \right].$$

Note that aggregate variables are normalized by both the long-run productivity growth rate, $1 + \mu$, and the population growth rate, $1 + \nu$, so that the balanced growth path of the economy is obtained as a steady state equilibrium.

⁸Since there are no aggregate shocks in the model economy, the government can perfectly predict the sum of accidental bequests during the period.

2.4 Recursive Competitive Equilibrium

The recursive competitive equilibrium of this model economy is defined as follows.

DEFINITION Recursive Competitive Equilibrium: Let $\mathbf{s} = (i, a, b_1, b_2, e_1, e_2, m)$ be the individual state of households, let $\mathbf{S}_t = (x(\mathbf{s}), W_{G,t})$ be the state of the economy, and let Ψ_t be the government policy schedule known at the beginning of period t ,

$$\Psi_t = \{C_{G,s}, tr_{LS,s}, \tau_{I,s}(\cdot), \tau_{P,s}(\cdot), tr_{SS,s}(\cdot), W_{G,s+1}\}_{s=t}^{\infty}.$$

A time series of factor prices and the government policy variables,

$$\Omega_t = \{r_s, w_s, C_{G,s}, tr_{LS,s}, \varphi_s, \bar{\tau}_{P,s}, \psi_s, W_{G,s}\}_{s=t}^{\infty},$$

where φ_t is a parameter of the individual income tax function, $\bar{\tau}_{P,t}$ is a parameter of the payroll tax function, and ψ_t is a parameter of the Social Security benefit function; the value functions of households, $\{v(\mathbf{s}, \mathbf{S}_s; \Psi_s)\}_{s=t}^{\infty}$, the decision rules of households,

$$\{c(\mathbf{s}, \mathbf{S}_s; \Psi_s), h_1(\mathbf{s}, \mathbf{S}_s; \Psi_s), h_2(\mathbf{s}, \mathbf{S}_s; \Psi_s), a'(\mathbf{s}, \mathbf{S}_s; \Psi_s), b'_1(\mathbf{s}, \mathbf{S}_s; \Psi_s), b'_2(\mathbf{s}, \mathbf{S}_s; \Psi_s)\}_{s=t}^{\infty},$$

and the distribution of households, $\{x_s(\mathbf{s})\}_{s=t}^{\infty}$, are in a recursive competitive equilibrium if, for all $s = t, \dots, \infty$, each household solves the optimization problem (1)-(8), taking $\mathbf{S}_s$ and Ψ_s as given; the firm solves its profit maximization problem (9)-(10); the government policy schedule satisfies (11)-(17); and the goods and factor markets clear. The economy is in a steady-state equilibrium thus on a balanced growth path if, in addition, $\mathbf{S}_s = \mathbf{S}_{s+1}$ and $\Psi_{s+1} = \Psi_s$ for all $s = t, \dots, \infty$.

3 Calibration

The present paper assumes one main baseline economy and three alternative baseline economies to check the robustness of the policy implications. In the alternative economies, the coefficient of relative risk aversion, γ , is reduced from 4.0 to 2.0; the auto-correlation parameter of the market wage process, ρ , is lowered from 0.98 to 0.96; and the market wage correlation between a husband and a wife at age 21 is increased from 0.5 to 1.0 independently.

For simplicity, the baseline economies are all assumed to be in a steady-state equilibrium, thus on a balanced-growth path, with the current-law OASI system with spousal and survivors benefits. In the baseline economies, the discount factor, β , is chosen so that the capital-output ratio, K/Y , is equal to 2.5; the additional cost parameter of female market work, κ , is chosen by targeting the ratio of average working hours of women to men, $\bar{h}_2/\bar{h}_1$, to be 0.75; and government consumption, C_G , and the OASI residual, TR_O , are set to balance the government budget and social security budget, respectively.

Table 1 shows the parameters and policy variables common in all of the baseline economies, and Table 2 shows the parameters and variables that vary by baseline assumptions.

3.1 Demographics

The maximum possible age, I , in the model economy is assumed to be $i = 80$, which corresponds to real age 100. This setting will cover more than 99% of the adult population in the United States. The retirement age, I_R , is fixed at $i = 46$ (real age 66). This is the current full retirement age for workers born in 1943-54 (Social Security Administration, 2010). The labor-augmenting productivity growth rate, μ , is 1.8% and the population growth rate, ν , is 1.0% in the model economy. These numbers are consistent with U.S. historical data. The survival rates of men and women at the end of each age, $\phi_{1,i}$ and $\phi_{2,i}$, are calculated from Table 4.C6 2005 Period Life Table in Social Security Administration (2010). The survival rates at the end of age 100 ($i = 80$) are replaced with zeros. For simplicity, the model abstracts from possible divorces and remarrying. Thus, the

Table 2: Parameters and Baseline Policy Variables That Vary by Model Assumptions

		Main baseline economy (Run 1)	Lower risk aversion (Run 2)	Lower wage persistence (Run 3)	Higher wage correlation (Run 4)
Coeff. of relative risk aversion	γ	4.0	2.0	4.0	4.0
Auto corr. parameter of log wage	ρ	0.98	0.98	0.96	0.98
Standard dev. of wage shocks	σ	0.17	0.17	0.2392	0.17
Wage corr. of couples at age 21	$\text{corr}(e_{11}, e_{21})$	0.5	0.5	0.5	1.0
Discount factor ^{*1}	β	1.0087	0.9910	0.9971	1.0100
Growth-adjusted discount factor ^{*2}	$\tilde{\beta}$	0.9894	0.9846	0.9781	0.9908
Cost par. of female market work ^{*3}	κ	0.0845	0.0274	0.0844	0.0820
Government consumption	$C_{G,t}$	4.8969	5.2445	5.3039	4.9680
Lump-sum transfers (bequests)	$tr_{LS,t}$	0.0089	0.0077	0.0082	0.0091
OASI residual	TR_O	0.4859	0.4303	0.4521	0.5377

^{*1} The capital-output ratio, K/Y , is targeted to 2.5. ^{*2} Calculated with $\tilde{\beta} = \beta(1 + \mu)^{\alpha(1-\gamma)}$. ^{*3} The relative working hours of women to men, $\bar{h}_2/\bar{h}_1$, is targeted to 0.75.

relative risk aversion, γ , is 4.0 in the main baseline economy, following Auerbach and Kotlikoff (1987) and Conesa, Kitao, and Krueger (2009), and it is later reduced to 2.0 in an alternative baseline economy (Run 2). With these parameter values, the elasticity of substitution of the husband's market work hours for the wife's hours is approximately $-\frac{1-\alpha}{\alpha} \frac{1}{(1-\alpha)(1-\gamma)-1} = 0.61$. The consumption adjustment factor for a married couple, λ is assumed to be 0.6, following Bernheim, Forni, Gokhale, and Kotlikoff (2003).⁹

The share parameter of capital stock in the production function, θ , is set at 3.0, which is close to the recent U.S. data. The depreciation rate of capital stock, δ , is 7.0% so that the interest rate, r , is equal to 5.0% in the baseline economies when the capital-output ratio is targeted to 2.5. Total factor productivity, A , is 0.9751 so that the average wage rate, w , is normalized to unity in the baseline economies. The population-weighted average of the median male wage rate, $w\bar{e}_1$, for ages 21-65 is also normalized to unity.

According to Table 5 of U.S. Bureau of Labor Statistics (2010), the average working hours of

⁹Attanasio, Low, and Sánchez-Marcos (2008) use the parameter value corresponding to $\lambda = 0.67$. The difference between 0.6 and 0.67 is almost negligible in the policy experiments.

female workers is calculated as 36.3 per week in 2009, and is 89.7% of that for male workers. The labor participation rate of women of ages between 25 and 54 is 75.8% in 2008, which is 83.8% of the labor participation rate of men. Thus, the ratio of women's market work hours to men's market work hours is approximately calculated as $89.7\% \times 83.8\% = 75.2\%$. Under the wage assumptions of men and women described in the next section, the model cannot replicate the lower working hours of women relative to men without introducing either the financial or utility cost for women to work outside the home and reduce their home production. The cost parameter of female market work is chosen so that the market work hour ratio, $\bar{h}_2/\bar{h}_1$, is equal to 0.75 in the baseline economies.

3.3 Market Wage Processes

The individual market wage rate (working ability), $e_{1,i}$ and $e_{2,i}$, of age i in the model economy is assumed to be

$$\ln e_{j,i} = \ln \bar{e}_{j,i} + \ln z_{j,i}$$

for $i = 1, \dots, I_R - 1$ and $j = 1, 2$, where $\bar{e}_{j,i}$ is the median wage rate of men or women at age i , and the persistent shock, $z_{j,i}$, is assumed to follow an AR(1) process,

$$\ln z_{j,i} = \rho \ln z_{j,i-1} + \epsilon_{j,i},$$

where $\epsilon_{j,i} \sim N(0, \sigma^2)$ and $\ln z_{j,1} \sim N(0, 0.5\sigma^2/(1 - \rho^2))$. The median market wage rates of men and women, $\bar{e}_{1,i}$ and $\bar{e}_{2,i}$, for ages between 21 and 65 are constructed with the 2009 median usual weekly earnings of full-time wage and salary workers by age and sex in the Current Population Survey (Table 1 in U.S. Bureau of Labor Statistics, 2010).

The median earnings of full-time workers would probably overestimate the working ability (the wage rate) of median workers, because some workers cannot choose a full-time job due to schooling or poor health conditions. The median earnings of all workers would underestimate the working ability, because some workers voluntarily choose not to work full time. For simplicity,

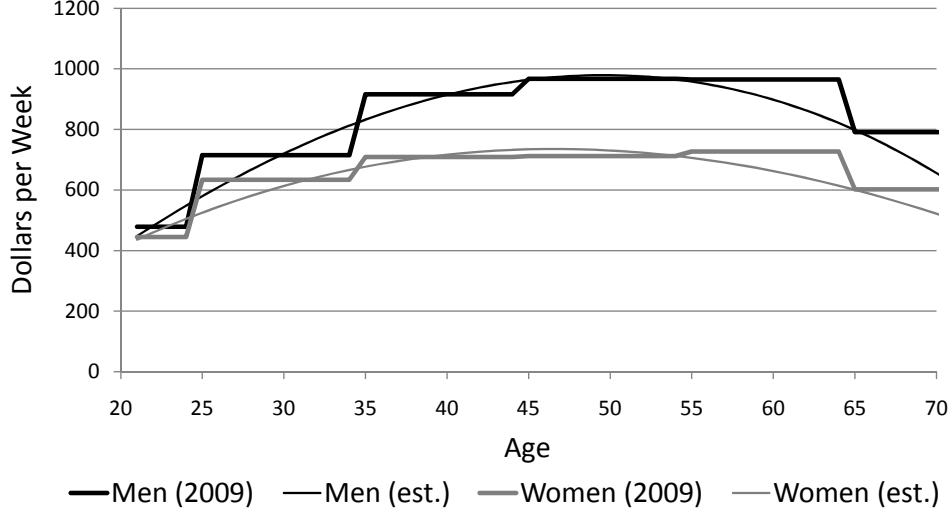


Figure 1: The Earnings Profile of Men and Women (Median usual weekly earnings of full-time wage and salary workers, 2009)

the present paper uses the former by adjusting the median earnings of full-time workers aged 24 or younger and aged 60 or older by 10% for schooling and deteriorated health conditions. Then it interpolates the median earnings profiles by OLS for ages 21-70. Figure 1 shows the original data and estimated values. When the full-time working hours in the model economy is $\alpha = 0.36$, the median earnings of male full-time workers is 0.36 in the baseline economy, and this number corresponds to the average of the median earnings of male full-time workers, $\$44,200 = \850×52 , calculated from Table 1 in the U.S. Bureau of Labor Statistics (2010).

The autocorrelation parameter, ρ , is assumed to be 0.98 and the standard deviation, σ , of the transitory shock is set at 0.17 in the main baseline economy; and these parameters are changed to $\rho = 0.96$ and $\sigma = 0.2392$ in the alternative baseline economy (Run 3).¹⁰ The log persistent shock, $\ln z_{j,i}$, is first discretized into 11 levels each by using Gauss-Hermite quadrature nodes, then 5 levels of $\ln z_{j,i}$ are generated by combining 4 nodes in each tail distribution into one node.¹¹ The unconditional probability distribution of the 5 nodes is $\pi_{j,i} = (0.0731, 0.2422, 0.3694, 0.2422, 0.0731)$ for $i = 1, \dots, I_R - 1$ and $j = 1, 2$. The tail nodes are combined because matching the tail dis-

¹⁰The standard deviation in the alternative economy is chosen so that $\lim_{i \rightarrow \infty} \sigma(\ln z_{j,i}) = \sigma / \sqrt{1 - \rho^2} = 0.8543$, which is equal to that in the main baseline economy.

¹¹See, for example, Judd (1998) for general calculation of Gauss-Hermite quadrature.

tributions of wage rates is less important for the present paper. The Markov transition matrix, $\Pi_{e_1,i} = [\pi(e_{1,i+1}^k | e_{1,i}^j)]$ and $\Pi_{e_2,i} = [\pi(e_{2,i+1}^k | e_{2,i}^j)]$ for $i = 1, \dots, I_R - 1$, that corresponds to $\rho = 0.98$ is calculated by using the bivariate normal distribution function as

$$\Pi_{e_1,i} = \Pi_{e_2,i} = \begin{pmatrix} 0.9585 & 0.0415 & 0.0000 & 0.0000 & 0.0000 \\ 0.0125 & 0.9554 & 0.0321 & 0.0000 & 0.0000 \\ 0.0000 & 0.0210 & 0.9580 & 0.0210 & 0.0000 \\ 0.0000 & 0.0000 & 0.0321 & 0.9554 & 0.0125 \\ 0.0000 & 0.0000 & 0.0000 & 0.0415 & 0.9585 \end{pmatrix},$$

and the transition matrix corresponding to $\rho = 0.96$ is

$$\Pi_{e_1,i} = \Pi_{e_2,i} = \begin{pmatrix} 0.9184 & 0.0816 & 0.0000 & 0.0000 & 0.0000 \\ 0.0246 & 0.9123 & 0.0631 & 0.0000 & 0.0000 \\ 0.0000 & 0.0414 & 0.9173 & 0.0414 & 0.0000 \\ 0.0000 & 0.0000 & 0.0631 & 0.9123 & 0.0246 \\ 0.0000 & 0.0000 & 0.0000 & 0.0816 & 0.9184 \end{pmatrix}.$$

3.4 Government's Policy Functions

The parameters of the Gouveia-Strauss type individual income tax function are estimated by OLS with the statutory marginal tax rates in 2009. One of the parameters, φ_t , is the limit of the marginal tax rate as taxable income goes to infinity. Thus, φ_t is first set at 0.35, the highest tax rate in 2009, in the baseline economy. The other two parameters, $\varphi_{m,1}$ and $\varphi_{m,2}$, are estimated by OLS (equally weighted for taxable income between \$0 and \$500,000), separately for married households filing jointly and single households. Then, φ_t is reduced to 0.30 from 0.35 to reflect the lower effective income tax rates. Individual income tax revenue, $T_{I,t}$, is calculated as 11.4% of GDP in the main baseline economy. The baseline economy assumes $C_{G,t} = T_{I,t}$ and $TR_{LS,t} = W_{G,t} = 0$ so that the government budget is balanced. Figure 2 shows the statutory and estimated marginal income tax rates when $\varphi_t = 0.35$.

The OASI payroll tax rate is 5.3% for an employee and 5.3% for an employer. Thus, $\bar{\tau}_{P,t}$ is set at 0.106. The thresholds to calculate primary insurance amounts (PIA) are set for each of

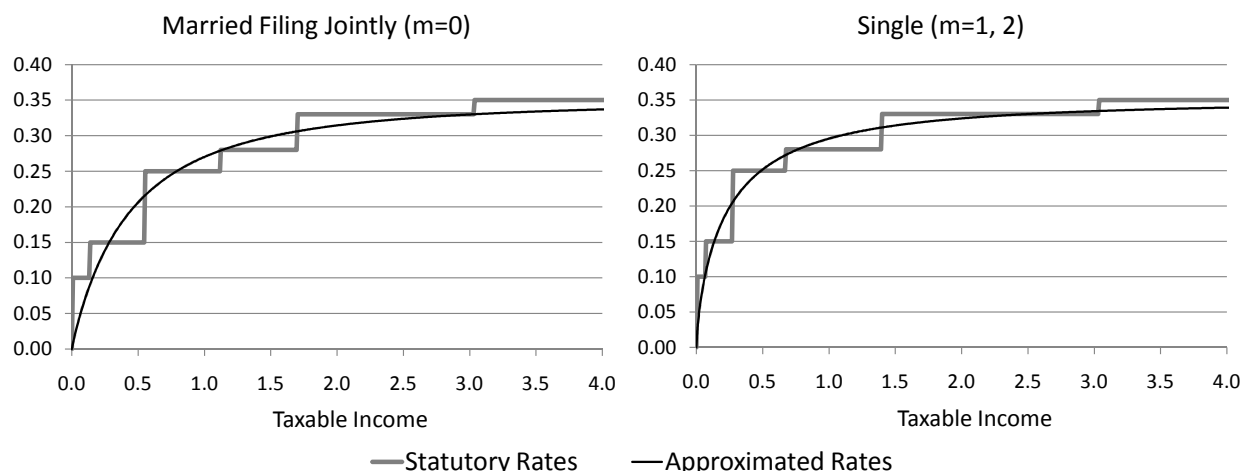


Figure 2: The Marginal Income Tax Rate Schedule of Married and Single Households

the age cohorts when they reach age 62 in the U.S. system. For simplicity, the growth-adjusted thresholds for all age cohorts are fixed in the model economy, and the PIA of each age cohort is adjusted later by using the long-term productivity growth rate and years from age 60. Thus, the model simply uses the thresholds for the age 62 cohort in 2009 after scale adjustment. The OASDI benefit adjustment factor, ψ_t , is 1.0 in the baseline economy. To balance the OASI budget, we also set the OASI residual, TR_O , at 0.4859, which is 18.7% of the OASI payroll tax revenue in the baseline economy. In 2008, the OASI benefit payments are 88.6% of the corresponding payroll tax revenue (Social Security Administration, 2010). The residual in the model economy is larger partly because the model assumes the full retirement age is 66 while it is between 65 and 66 for the current recipients in the U.S. economy. The residual also consists of survivors benefits received by workers' children and parents that are not considered in the present paper.

3.5 The Property of the Baseline Economy

Table 3 summarizes the shares of elderly women by type of benefit in the 2008 data and in the model economies.¹² The first row of the table shows that 44.2% of women aged 62 or older receive their own workers benefits, 22.3% receive spousal benefits, and 33.4% receive survivors

¹²Karen Kopecky and Tatyana Koreschkova suggested the author to check the distribution of female recipients by type of benefit in the data (Table 5.A14 in Social Security Administration, 2010).

Table 3: The Distribution of Elderly Women by Type of Benefit (%)

	Worker's benefit	Wife's benefit	Widow's benefit	
Data (2008)* ¹	44.2	22.3	33.4	Social Security Administration (2010)
Run 1	56.4	16.8	26.8	Main baseline economy
Run 2	54.3	19.2	26.4	Lower risk aversion
Run 3	57.3	16.4	26.3	Lower wage persistence
Run 4	57.7	14.7	27.6	Higher wage correlation
Run 1'	44.9	23.5	31.6	Main baseline with $\bar{h}_2/\bar{h}_1 = 0.60$

*¹ Women aged 62 or older. Author's calculation from Table 5.A14 in Social Security Administration (2010).

benefits in 2008. The second row (Run 1) shows that the corresponding shares of elderly women are 56.4%, 16.8%, and 26.8% in the main baseline economy. The share of women that receive their own worker's benefits is 12.2 percentage points higher. The share of worker's benefits is also higher in the three alternative baseline economics (Runs 2-4).

The model in the present paper, calibrated to the 2009 U.S. economy does not replicate the shares of elderly women by type of benefits in 2008, because the baseline economy is assumed to be in a steady-state equilibrium (or on the balanced growth path) and the the wage rate and the labor participation rate of current elderly women observed in the data are much lower when they are in the prime working years. The median earnings of full-time female workers aged 21-65 relative to that of male workers (estimated by OLS) is on average 79.6% in 2009, while the corresponding relative median earnings aged 16 and over is 64.0% in 1980, which is about 20% lower than that in 2009. The labor participation of women aged 25-54 relative to that of men is 83.8% in 2009, as discussed in the previous section. In 1975, 1980, and 1985, the corresponding numbers are 58.4%, 67.9%, and 74.1%, respectively, and these are also on average 20% lower than that in 2009 (Bureau of Labor Statistics, 2006). The last row (Run 1') of the table shows the shares of elderly women by type of benefit are very close to those in the 2008 data when the main baseline economy is recalibrated by assuming the female market wage rates, $e_{2,i}$, are 20% lower and by targeting the ratio of average working hours, $\bar{h}_2/\bar{h}_1$ to be 0.60 instead of 0.75.

4 Removing Spousal and Survivors Benefits

Policy experiments of the present paper are simple. The economy is assumed to be in the initial steady-state equilibrium (or on the balanced growth path) in period 0. Starting at the beginning of period 1, the government removes the spousal and survivors benefits of the current OASI program cohort by cohort in a phased in manner. More specifically, for households aged 61 ($i = 41$) or older in period 1, their OASI benefit function is unchanged, because it is too late for these households to adjust their labor supply to the policy change. Thus, for $i - (t - 1) \geq 41$ and $t \geq 1$,

$$\begin{aligned} tr_{SS,t}^0(i, b_1, b_2, m) \\ = \begin{cases} \psi_t(\psi_0\psi_T^{-1}) \max[\psi(i, b_1) + \psi(i, b_2), 1.5\psi(i, b_1), 1.5\psi(i, b_2)] & \text{if } m = 0, \\ \psi_t(\psi_0\psi_T^{-1}) \max[\psi(i, b_1), \psi(i, b_2)] & \text{if } m = 1, 2, \end{cases} \end{aligned}$$

where ψ_0 and ψ_T are benefit adjustment parameters in the initial and final steady states, respectively, and ψ_t is adjusted to balance the OASI budget in each transition period. For households aged 21 ($i = 1$) or younger, their OASI benefit function is fully replaced by the new benefit function without spousal and survivors benefits, i.e., for $i - (t - 1) \leq 1$ and $t \geq 1$,

$$tr_{SS,t}^1(i, b_1, b_2, m) = \begin{cases} \psi_t[\psi(i, b_1) + \psi(i, b_2)] & \text{if } m = 0, \\ \psi_t\psi(i, b_j) & \text{if } m = j = 1, 2. \end{cases}$$

Finally, for households aged between 22 ($i = 2$) and 60 ($i = 40$), their possible spousal and survivors benefits are reduced cohort by cohort. The OASI benefit function is set to be the weighted average of the above two functions, i.e., for $2 \leq i - (t - 1) \leq 40$ and $t \geq 1$,

$$tr_{SS,t}(i, b_1, b_2, m) = \frac{i - t}{40} tr_{SS,t}^0(i, b_1, b_2, m) + \left(1 - \frac{i - t}{40}\right) tr_{SS,t}^1(i, b_1, b_2, m).$$

Government's Financing Assumptions. Any changes in the current Social Security system would change the government's income and payroll tax revenue. If spousal and survivors ben-

efits were eliminated, the government's benefit expenditure would decline, and the payroll tax revenue would likely increase due to larger labor supply, other things being equal. For simplicity, the OASI budget is balanced in each period in the model economy, the payroll tax rate, $\bar{\tau}_{P,t}$, is fixed at the baseline level, and the benefits are changed proportionally in each period by the adjustment factor, ψ_t , to match the payroll tax revenue. For the rest of the government budget, the removal of the spousal and survivors benefits would likely increase labor supply, thus increasing individual income tax revenue. The rest of the government budget is also balanced in each period, and either government consumption, $C_{G,t}$, lump-sum transfer, $tr_{LS,t}$, or marginal income tax rate parameter φ_t , is changed in each period to balance the budget.

The government's financing rules assumed in this paper are summarized as follows:

- (a) $C_{G,t} \leftarrow C_{G,t} = T_{I,t}(\varphi_0) - TR_{LS,t}(tr_{LS,0}), \quad W_{G,t} = 0;$
- (b) $tr_{LS,t} \leftarrow TR_{LS,t}(tr_{LS,t}) = T_{I,t}(\varphi_0) - C_{G,0}, \quad W_{G,t} = 0;$
- (c) $\varphi_t \leftarrow T_{I,t}(\varphi_t) = C_{G,0} + TR_{LS,t}(tr_{LS,0}), \quad W_{G,t} = 0;$
- (a) - (c) $\psi_t \leftarrow TR_{SS,t}(\psi_t) = T_{P,t}(\bar{\tau}_{P,0}) - TR_O.$

Welfare Measure. The welfare gains or losses of age 21 ($i = 1$) households at the beginning of $t = 1, \dots, \infty$ are calculated by the uniform percent changes, $\lambda_{1,t}$, in the baseline consumption path that would make their expected lifetime utility equivalent with the expected utility after the policy change, that is,

$$\lambda_{1,t} = \left[\left(\frac{E v(\mathbf{s}_1, \mathbf{S}_t; \mathbf{\Psi}_t)}{E v(\mathbf{s}_1, \mathbf{S}_0; \mathbf{\Psi}_0)} \right)^{\frac{1}{\alpha(1-\gamma)}} - 1 \right] \times 100.$$

Similarly, the average welfare changes of households of age i at the time of policy change ($t = 1$) are calculated by the uniform percent changes, $\lambda_{i,1}$, required in the baseline consumption path so that the rest of the lifetime value would be equal to the rest of the lifetime value after the policy

change, that is,

$$\lambda_{i,1} = \left[\left(\frac{E v(\mathbf{s}_i, \mathbf{S}_1; \Psi_1)}{E v(\mathbf{s}_i, \mathbf{S}_0; \Psi_0)} \right)^{\frac{1}{\alpha(1-\gamma)}} - 1 \right] \times 100.$$

Note that $\lambda_{i,1}$ for $i = I, \dots, 1$ shows the cohort-average welfare changes of all current households alive at the time of policy change, and $\lambda_{1,t}$ for $t = 2, \dots, \infty$ shows the cohort-average welfare changes of all future households.

4.1 Long-Run Effects on Macro Economy and Welfare

Table 4 shows the long-run effects of removing spousal and survivors benefits under the government financing assumptions of (a) increasing government consumption, (b) introducing lump-sum transfers, and (c) decreasing marginal income tax rates.

In Run 1 (a), the government is assumed to increase its consumption to balance the budget. By removing spousal and survivors benefits, women's market work hours would increase by 4.6% and labor supply in efficiency units would increase by 2.2% from the baseline economy. The increase in the latter is smaller because women with lower wages would increase market work hours more than those with higher wages. Men's market work hours would increase only by 0.3%, and labor supply would increase by 0.1%. The ratio of women's market work hours to men's work hours would rise by 3.3 percentage points from 75.0% to 78.3%, and the ratio of women's labor supply to men's labor supply would rise by 1.4 percentage points from 67.4% to 68.8%.

Total labor supply in efficiency units would increase by 0.9%, and capital stock (national wealth) and total output (GDP) would increase by 1.9% and 1.2%, respectively. The OASI payroll tax revenue would increase by 1.2%. The increase rate would be higher than that of total labor supply, because those whose labor income are below the maximum taxable earnings would increase their labor supply more than those with higher labor income in the baseline economy. The OASI benefit adjustment factor would increase by 16.4%. By assumption, the removal of spousal and survivors benefits would allow the government to increase PIA (or workers benefits) even if the

Table 4: The Long-Run Effects of Removing Spousal and Survivors Benefits in the Main Baseline Economy (% changes from the baseline economy)

Financing assumption	1 (a) Increasing government consumption	1 (b) Increasing lump-sum transfers	1 (c) Reducing income tax rates
Capital stock (national wealth)	1.9	1.7	2.5
Labor supply	0.9	0.8	1.1
Total output (GDP)	1.2	1.1	1.5
Private consumption	0.9	1.0	1.5
Market work hours: men	0.3	0.0	0.4
Market work hours: women	4.6	4.3	4.9
Labor supply (efficiency units): men	0.1	0.0	0.3
Labor supply (efficiency units): women	2.2	2.0	2.4
Working hour ratio (women/men)* ¹	3.3	3.2	3.4
Labor income ratio (women/men)* ¹	1.4	1.4	1.4
Interest rate	-1.6	-1.6	-2.2
Average wage rate	0.3	0.3	0.4
Welfare of age 21 households	0.3	0.8	0.6
Government consumption	1.5	0.0	0.0
Lump-sum transfers* ²	1.2	2.5	1.2
Marginal Income tax rates	0.0	0.0	-1.9
OASI payroll tax revenue	1.2	1.0	1.4
OASI benefit adjustment	16.4	16.4	16.6

*¹ Changes in percentage points. In the baseline economy, the working hour ratio is 75.0%, and the labor income ratio is 67.4%. *² Change as a percentage of the baseline tax revenue.

payroll tax revenue is unchanged.

Because of the higher economic activity and tax revenue, the government would be able to increase its consumption by 1.5% to keep its budget balanced.¹³ Since part of the increased resource is consumed by the government, private consumption would increase only by 0.9%. The interest rate would fall by 1.6% or 0.08 percentage points, and the average wage rate would rise 0.3%. The average welfare gain of age 21 households in the consumption equivalent variation measure is 0.3% under this financing assumption.

¹³The government consumption and individual income tax revenue are both 11.4% of GDP in the baseline economy.

In Run 1 (b), the government is assumed to distribute extra tax revenue to all households as lump-sum transfers to balance the budget. The main difference from Run 1 (a) is that Run 1 (b) would have an income effect due to the lump-sum transfers. Women's market work hours would increase by 4.3% and labor supply in efficiency units would increase by 2.0%. The increase rates are both lower than those in Run 1 (a). Under this assumption, total labor supply, capital stock, and GDP would increase by 0.8%, 1.7%, and 1.1%, respectively. Individual tax revenue would increase by 1.3%. This extra income tax revenue as well as the increased revenue from accidental bequests would be distributed as lump-sum transfers. Private consumption would increase by 1.0%, which is slightly higher than that in Run 1(a). The changes in the interest rate and the wage rate would be about the same levels as those in Run 1 (a). The average welfare of age 21 households would increase by 0.8%.

Run 1 (c) assumes that the government would reduce the marginal income tax rates proportionally to balance the government budget. The main difference from Run 1 (b) is an additional substitution effect by the marginal tax rate cuts. Under this assumption, women's market work hours would increase most by 4.9%, and labor supply would increase by 2.4%. Total labor supply, capital stock, and GDP would increase by 1.1%, 2.5%, and 1.5%, respectively. Private consumption would also increase by 1.5%. The increase rates of macroeconomic variables are all significantly higher than those in Runs 1 (a) and 1 (b). The government would be able to reduce the marginal income tax rates proportionally by 1.9% to balance the budget. The interest rate would fall by 2.2%, and the wage rate would rise by 0.4%. The average welfare of age 21 households would increase by 0.6%.

4.2 Long-Run Effects on Life-Cycle Behaviors

Figure 3 shows the long-run effects of removing spousal and survivors benefits over the life cycle. In each of the 8 charts, the solid black line shows the profile of the main baseline economy, the dashed blue line shows Run 1 (a), the long-dashed red line shows Run 1 (b), and the short-dashed green line shows Run 1 (c).

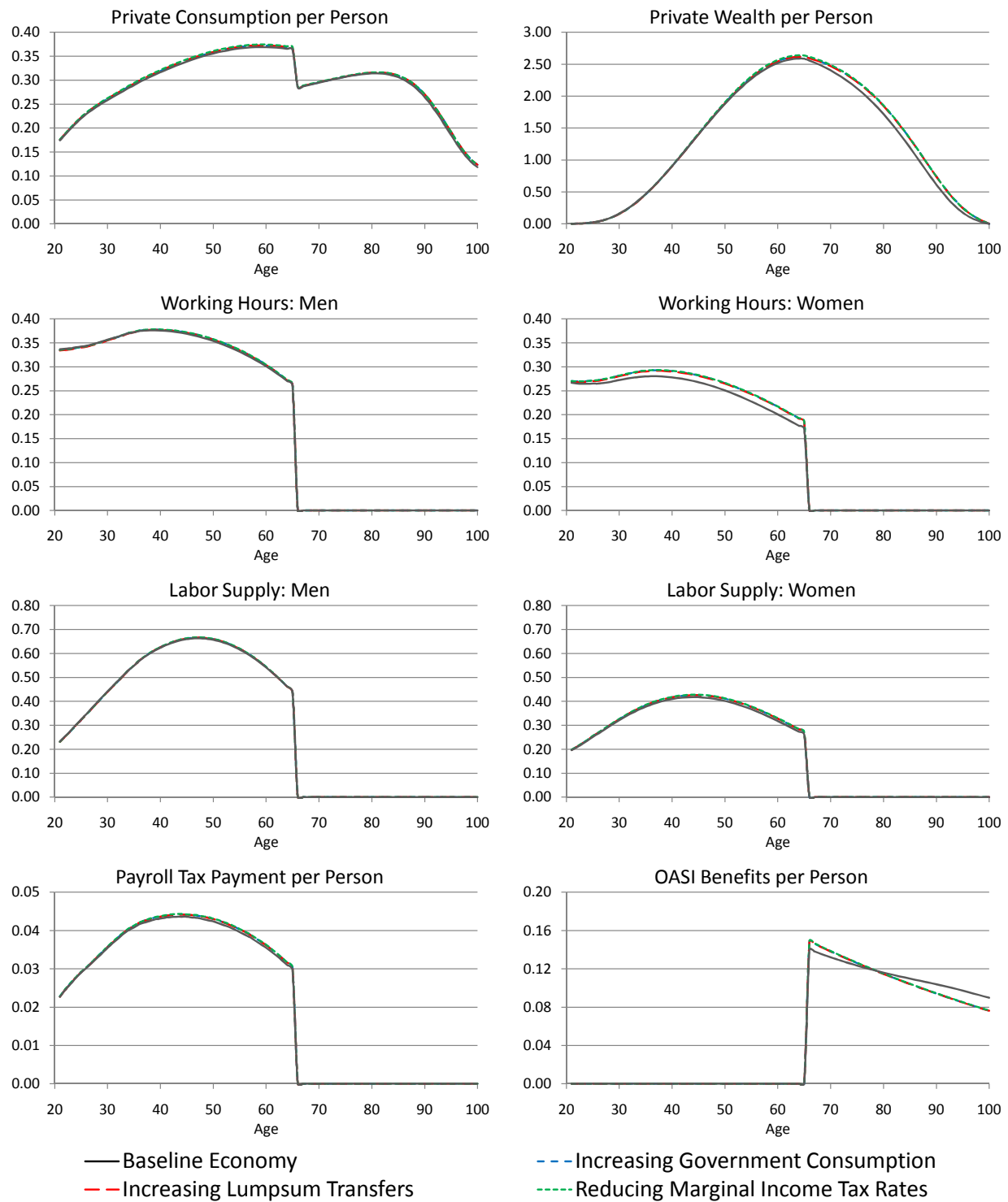


Figure 3: The Long-Run Effects of Removing Spousal and Survivors Benefits over the Life Cycle

Men's market work hours are mildly hump-shaped. Women's market work hours are also hump-shaped but have a tendency to decline starting in their late 30s. As the husband and wife get older, the wage disparity tends to increase, which makes the wife's market work hours relatively shorter. In addition, their average historical earnings approach to the final values. If the wife's expected PIA was less than half of the husband's expected PIA, the wife would tend to work less, because the increased OASI payroll tax payment would not likely increase her OASI benefits.

When spousal and survivors benefits were removed, the increase in market work hours would be larger for women than men, because women's wage rates are on average lower than those of men. Also, the increase in market work hours would be larger for those near the retirement age, because workers are more certain about their own future PIA and OASI benefits. Regarding private consumption and wealth, the positive effects of the policy change tend to increase as workers get older, and the increase rates are largest when the government reduces the marginal income tax rates proportionally to balance the budget.

In the absence of spousal and survivors benefits, the OASI benefits would be on average higher for retired households aged 78 or younger but lower for those aged 79 or older. In the baseline economy, per capita OASI benefits are on average increasing, because some widows (widowers) switch their benefits from their own benefits to survivors benefits when their spouses die. After the policy change, as households get older, the number of widow(er)ed people would increase but their OASI benefits would be lower because of the removal of survivors benefits.

Table 5 shows the long-run changes in market work hours of age 40 ($i = 20$) married households from the baseline economy. Rows, $e_1^1, \dots, e_1^5$, are the husband's wage levels at age 40, and the columns, $e_2^1, \dots, e_2^5$, are the wife's wage levels. Since some people do not work outside the home, the changes in market work hours of husbands and wives are calculated as a percentage of average market hours of men and women, respectively, in the baseline economy.

Under all 3 government financing assumptions, the husband's market work hours would increase significantly when the state (the combination of e_1 and e_2) of the household was near (but not at) the upper-right corner of each panel, i.e., one of (e_1^1, e_2^3) , (e_1^1, e_2^4) , (e_1^2, e_2^4) , (e_1^2, e_2^5) , and

Table 5: Long-run Changes in Hours of Market Work of Age Married 40 Households (changes as a percentage of the baseline hours)

		Husband					Wife				
		e_2^1	e_2^2	e_2^3	e_2^4	e_2^5	e_2^1	e_2^2	e_2^3	e_2^4	e_2^5
1 (a)	e_1^1	-1.04	-0.06	6.93	3.94	0.00	12.97	-0.72	-1.37	0.09	1.82
Increasing	e_1^2	-0.60	-1.42	0.15	5.85	7.80	18.79	3.69	-1.05	-1.12	1.05
government	e_1^3	0.11	-1.12	-1.51	0.31	4.56	0.00	17.49	2.76	-0.70	-0.02
consumption	e_1^4	2.80	1.82	0.59	-0.41	-0.09	0.00	8.84	11.23	2.05	-0.62
	e_1^5	1.87	1.55	1.10	0.10	-0.33	0.00	0.00	18.65	6.59	-0.48
1 (b)	e_1^1	-1.71	-0.54	6.55	3.74	0.00	11.74	-1.30	-1.73	-0.18	1.70
Increasing	e_1^2	-0.92	-1.73	-0.10	5.66	7.67	17.54	3.22	-1.35	-1.31	0.94
lump-sum	e_1^3	-0.07	-1.32	-1.67	0.17	4.45	0.00	17.11	2.50	-0.87	-0.12
transfers	e_1^4	2.67	1.70	0.49	-0.51	-0.19	0.00	8.59	11.02	1.91	-0.70
	e_1^5	1.80	1.48	1.03	0.04	-0.37	0.00	0.00	18.51	6.48	-0.55
1 (c)	e_1^1	-1.05	-0.08	7.09	4.15	0.00	12.99	-0.72	-1.21	0.38	2.08
Reducing	e_1^2	-0.56	-1.35	0.29	6.12	8.14	19.16	3.86	-0.83	-0.83	1.31
income	e_1^3	0.28	-0.97	-1.33	0.55	4.89	0.00	17.89	3.08	-0.39	0.23
tax rates	e_1^4	2.99	2.00	0.76	-0.24	0.23	0.00	9.43	11.72	2.41	-0.38
	e_1^5	2.05	1.72	1.27	0.26	-0.19	0.00	0.00	19.18	7.04	-0.26

* Rows, $e_1^1, \dots, e_1^5$, are the husband's wage rates at age 40 ($i = 20$) from the lowest to the highest, and columns, $e_2^1, \dots, e_2^5$, are the corresponding wife's wage rates.

(e_1^3, e_2^5). For households in these states, the husband's market wage rate is lower relative to his wife's wage rate, and the husband expects to receive spousal and survivors benefits when these benefits are available. Depending on the government financing assumption and the state, the working hours of age 40 husbands in these states would increase on average by 3.7-7.8% as a percentage of the average baseline market hours.

Similarly, the wife's market work hours would increase most when the state of the household is on or below the diagonal, i.e., one of (e_1^1, e_2^1), (e_1^2, e_2^1), (e_1^3, e_2^2), (e_1^4, e_2^2), (e_1^4, e_2^3), and (e_1^5, e_2^3). In these states, the wife's market wage is significantly lower relative to her husband's. However, if the wife's wage rate was one of the lowest, e_2^1 , and her husband's wage rate was high enough, e_1^3 or higher, the wife would stay and work at home even after the removal of spousal and survivors benefits.

4.3 Transition Effects on Macro Economy and Welfare

Figure 4 shows the transition paths of a 40-year phased-in removal of spousal and survivors benefits from the current OASI program. In each of these 8 charts, the dashed blue line shows the percent changes from the baseline economy in Run 1 (a), the long-dashed red line shows the percent changes in Run 1 (b), and the short-dashed green line shows the percent changes in Run 1 (c).

Women's market work hours would jump up by 1.6-1.8% in the first year of the policy change, then the work hours would increase gradually to the long-run steady-state levels, which are 4.3-4.9% higher than the baseline levels. The increase is largest when the marginal tax rates are reduced and smallest when lump-sum transfers are introduced. Men's work hours would decrease by 0.08% or increase by 0.04% in the first year, but the work hours would also increase gradually to the long-run levels. Total labor supply in efficiency units would also increase by 0.2-0.3% in the first year. Total output and private consumption would show the same pattern as that of labor supply, i.e., these jump in the first year and increase gradually to the long-run steady-state levels.

The spousal and survivors benefits are partially removed in a phased-in manner, starting from age 60 households to age 22 households at the time of the policy change. Age 21 households at the policy change are the first (oldest) age cohort for whom spousal and survivors benefits are completely removed. Thus, it will take 80 years for these benefits to be completely removed from the model economy.

The bottom right chart shows the welfare change by age cohort. The horizontal axis is the age of household cohort when the policy is changed ($t = 1$). The vertical line in the middle indicates the youngest age cohort at the time of policy change. Households shown left of the vertical line are current households aged between 21 and 100 at the time of the policy change, and those shown right of the vertical line are future households aged 20 or younger.

The current elderly households aged 66 ($i = 46$) or older would be better off by the policy change. Their OASI benefit function is unaffected by the policy change but their OASI benefits would increase slightly because of the higher payroll tax revenue due to larger labor supply. The

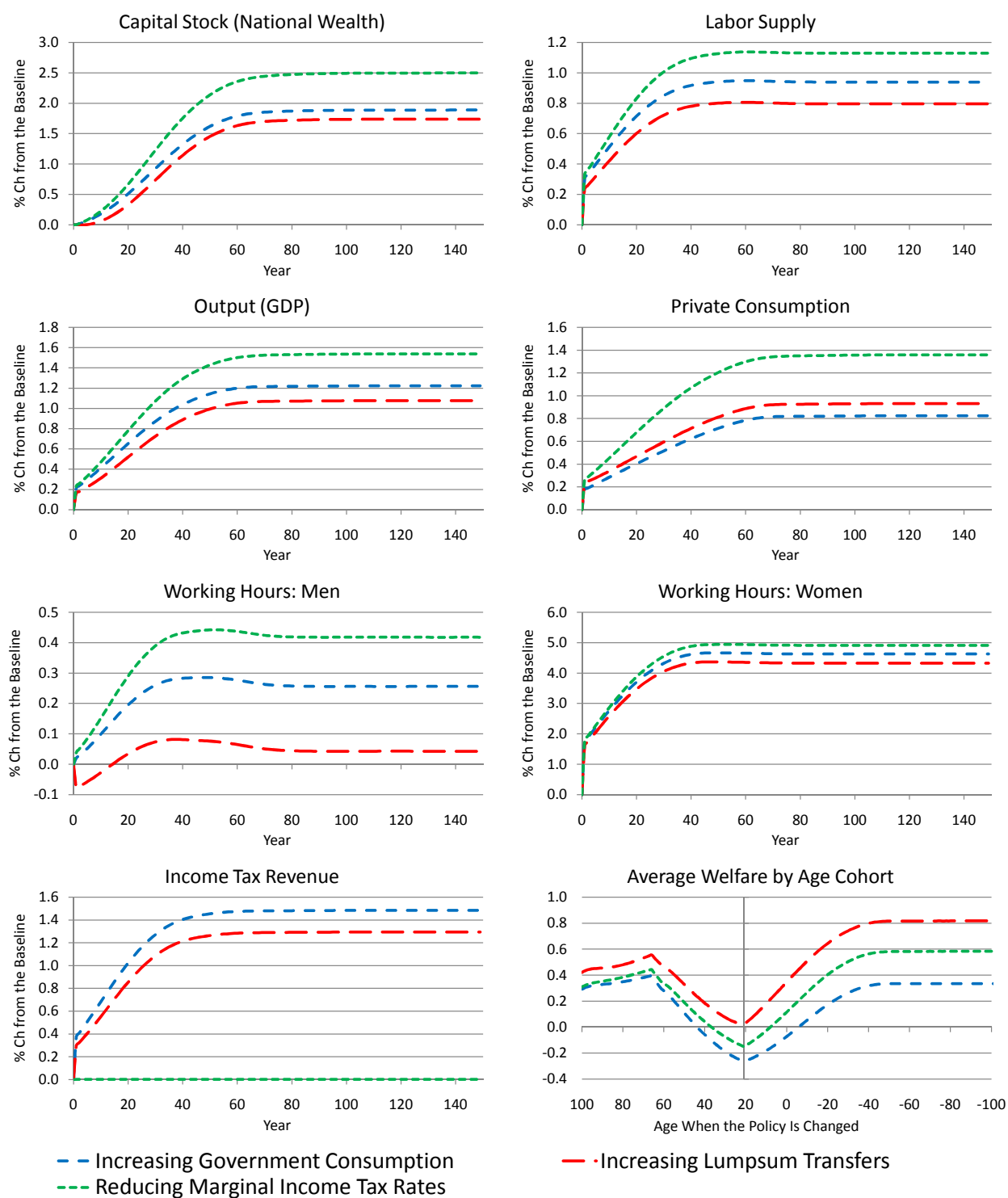


Figure 4: The Transition Effects of Removing Spousal and Survivors Benefits

interest income would also increase in the short run. The spousal and survivors benefits of current households aged 22 ($i = 2$) and 60 ($i = 40$) are partially removed, depending on their age in period 1. Due to the phased-in policy change, the welfare gains/losses of these households would be smaller/larger for younger households.

When additional government tax revenue are used for government consumption (waste), households aged between 43 and -5 at the time of policy change would be on average worse off. If the additional tax revenue were distributed to households as lump-sum transfers, all of the current and future age cohorts would be on average better off. If the marginal income tax rates are reduced to balance the government budget, the welfare effects are somewhere between those under the first two assumptions. Under all 3 financing assumptions, the welfare gain of the age 21 households at the time of policy change ($t = 1$) would be the smallest among all age cohorts.

Removing spousal and survivors benefits could possibly make all of the current and future age cohorts on average better off. However, this does not mean the policy change is Pareto improving in the heterogeneous-agent economy. Table 6 shows the welfare gains and losses of age 21 households in year 1 and in the long run by their initial wage levels.

Rows, $e_1^1, \dots, e_1^5$, are the husband's wage levels at age 21 ($i = 1$), and the columns, $e_2^1, \dots, e_2^5$, are the wife's wage levels. Under all 3 financing assumptions, the policy change—removing spousal and survivors benefits—would hurt households most when the husband's wage is one of the highest, e_1^4 or e_1^5 , and the wife's wage rate is the lowest, e_2^1 . The age 21 households of these wage combinations in year 1 would be worse off by 3.00-3.25% in a consumption equivalence measure. The age 21 households on the diagonal and somewhat above the diagonal tend to be better off by this policy, because they are less likely receiving spousal and survivors benefits after retirement. Those households shown in the lower triangle tend to be worse off.

4.4 Individual Contributions of Spousal and Survivors Benefits

This section analyzes the long-run effects of spousal benefits and survivors benefits separately and show the relative importance of these 2 benefits. Table 7 shows the results.

Table 6: Welfare Change of Age 21 Households in the Transition Path

		At the policy change ($t = 1$)					In the final steady state ($t = \infty$)				
		e_2^1	e_2^2	e_2^3	e_2^4	e_2^5	e_2^1	e_2^2	e_2^3	e_2^4	e_2^5
1 (a)	e_1^1	-0.64	0.19	-0.14	-0.95	-1.42	0.50	1.07	0.51	-0.48	-1.16
Increasing	e_1^2	-1.67	-0.10	0.32	-0.01	-0.60	-0.85	0.60	0.90	0.44	-0.32
government	e_1^3	-2.62	-1.00	0.08	0.38	0.13	-2.03	-0.45	0.57	0.79	0.43
consumption	e_1^4	-3.25	-2.06	-0.63	0.21	0.40	-2.85	-1.66	-0.23	0.56	0.68
	e_1^5	-3.22	-2.45	-1.35	-0.25	0.29	-3.00	-2.21	-1.08	0.02	0.52
1 (b)	e_1^1	-0.09	0.61	0.18	-0.70	-1.24	1.56	1.82	1.06	-0.09	-0.89
Increasing	e_1^2	-1.24	0.23	0.59	0.21	-0.44	-0.11	1.18	1.35	0.78	-0.08
lump-sum	e_1^3	-2.29	-0.73	0.30	0.55	0.27	-1.51	-0.01	0.93	1.07	0.63
transfers	e_1^4	-3.00	-1.85	-0.45	0.35	0.52	-2.47	-1.33	0.04	0.79	0.86
	e_1^5	-3.04	-2.29	-1.21	-0.13	0.38	-2.74	-1.97	-0.88	0.19	0.66
1 (c)	e_1^1	-0.60	0.25	-0.06	-0.83	-1.26	0.66	1.24	0.72	-0.23	-0.83
Reducing	e_1^2	-1.61	-0.03	0.42	0.13	-0.42	-0.70	0.79	1.13	0.72	0.04
income	e_1^3	-2.54	-0.90	0.21	0.54	0.33	-1.86	-0.23	0.84	1.11	0.82
tax rates	e_1^4	-3.14	-1.93	-0.47	0.40	0.64	-2.62	-1.39	0.08	0.94	1.13
	e_1^5	-3.05	-2.27	-1.14	-0.01	0.56	-2.66	-1.85	-0.69	0.46	1.03

* The equivalence variation measure in consumption, %. Rows, $e_1^1, \dots, e_1^5$, are the husband's wage rates at age 21 ($i = 1$) from the lowest to the highest, and columns, $e_2^1, \dots, e_2^5$, are the corresponding wife's wage rates.

The second panel of Table 7 shows the effects of removing spousal benefits only. Women's market work hours would increase by 2.1-2.4%. The increase rates are 49% of those when removing both benefits. Interestingly, men's work hours would increase by 0.2-0.4% and more than those in the main experiment. Overall, total labor supply in efficiency units would increase by 0.5-0.7%, capital stock would increase by 0.0-0.4%, and total output would increase by 0.3-0.6%. Removing spousal benefits would not increase household wealth very much. The welfare changes of age 21 households are on average very small. These households would be better off by at most 0.2% in the long run.

The third panel of the same table shows the effect of removing survivors benefits only. Women's market work hours would increase by 3.3-3.9%. Removing survivors benefits account for 76-80% of the increase in female working hours. We also see that the effect of removing these 2 types

Table 7: The Individual Contributions of Spousal and Survivors Benefits (% changes from the baseline economy)

Financing assumption	(a) Increasing government consumption	(b) Increasing lump-sum transfers	(c) Reducing income tax rates
1. Removing both spousal and survivors benefits			
Total output (GDP)	1.2	1.1	1.5
Labor supply (efficiency units)	0.9	0.8	1.1
Market work hours: men	0.3	0.0	0.4
Market work hours: women	4.6	4.3	4.9
Welfare of age 21 households	0.3	0.8	0.6
1A. Removing spousal benefits only			
Total output (GDP)	0.4	0.3	0.6
Labor supply (efficiency units)	0.6	0.5	0.7
Market work hours: men	0.3	0.2	0.4
Market work hours: women	2.3	2.1	2.4
Welfare of age 21 households	-0.1	0.2	0.1
1B. Removing survivors benefits only			
Total output (GDP)	1.3	1.1	1.6
Labor supply (efficiency units)	0.9	0.8	1.2
Market work hours: men	0.0	-0.3	0.1
Market work hours: women	3.6	3.3	3.9
Welfare of age 21 households	0.4	0.9	0.7

of benefits are not additively separable. Men's market work hours would decrease by 0.3% or increase by 0.1%. Total labor supply would increase by 0.8-1.2%, capital stock would increase by 2.0-2.8%, and total output would increase by 1.1-1.6%. Surprisingly, the increase rates of these macroeconomic variables are about the same or slightly higher than those when both benefits are removed. The welfare effects are also larger. The age 21 households would be better off on average by 0.4-0.9%.

In the presence of survivors benefits, removing spousal benefits would increase labor supply in efficiency units by 0.5-0.7% (Run 1A). However, in the absence of survivors benefits, removing spousal benefits would possibly decrease labor supply by 0.1% (Runs 1B and 1), although total working hours would still increase.

5 Policy Reform in the Alternative Baseline Economies

How would the effects of removing spousal and survivors benefits differ depending on the model assumptions? This section shows the policy effects in 3 alternative baseline economies: the economy with a lower coefficient of relative risk aversion (Run 2), the economy with lower persistence in wage shocks (Run 3), and the economy consisting of married couples with higher wage correlation (Run 4). Table 8 shows the results of the same policy experiments in these 3 alternative economies as well as those in the main baseline economy.

The household's preference assumed in this model is additively separable between husband and wife as well as across time. Thus, when we reduce the coefficient of relative risk aversion, γ , from 4.0 to 2.0, it will also change the intra-temporal (intra-household) elasticity of substitution of husband's market work hours for wife's work hours. The elasticity of substitution is increased to $-\frac{1-\alpha}{\alpha} \frac{1}{(1-\alpha)(1-\gamma)-1} = 1.08$ from 0.61. The second panel (Run 2) of the table shows the results of the policy experiments. With the higher intra-household elasticity of substitution, women's market work hours would increase by 5.1-5.6% from the new baseline economy. The increase rates are 0.7-0.8 percentage points higher than those in the main policy experiments. The increase rates in GDP would be lower in this economy, and the welfare changes in age 21 households would also be lower by 0.0-0.2 percentage points.

How about the effect of removing spousal and survivors benefits in the economy with lower wage persistence? If the transitory wage shocks are less persistent, households can predict their future wage rates and OASI primary insurance amounts less accurately. Thus, the labor supply reaction of households to the policy change will be smaller. The third panel (Run 3) shows the results of the policy experiments. In the economy with less persistent wage shocks, women's market work hours would increase by 3.6-3.8% from the new baseline economy. The increase rates in working hours are 1.0-1.1 percentage points higher than those in the main baseline economy. Total output would increase by 1.0-1.4%. The increase rates are 0.1 percentage points lower. However, the welfare effects are slightly larger compared to those in the main baseline economy.

The last panel (Run 4) of Table 8 shows the effects of removing spousal and survivors benefits

Table 8: The Long-Run Effects of Removing Spousal and Survivors Benefits in the Alternative Baseline Economies (% changes from the baseline economy)

Financing assumption	(a) Increasing government consumption	(b) Increasing lump-sum transfers	(c) Reducing income tax rates
1. Main baseline economy ($\gamma = 4.0$, $\rho = 0.98$, $\text{corr}(e_{1,1}, e_{2,1}) = 0.5$)			
Total output (GDP)	1.2	1.1	1.5
Labor supply (efficiency units)	0.9	0.8	1.1
Market work hours: men	0.3	0.0	0.4
Market work hours: women	4.6	4.3	4.9
Welfare of age 21 households	0.3	0.8	0.6
2. Lower relative risk aversion ($\gamma = 2.0$, $\rho = 0.98$, $\text{corr}(e_{1,1}, e_{2,1}) = 0.5$)			
Total output (GDP)	1.0	0.9	1.3
Labor supply (efficiency units)	0.9	0.8	1.0
Market work hours: men	-0.1	-0.3	0.0
Market work hours: women	5.4	5.1	5.6
Welfare of age 21 households	0.3	0.6	0.5
3. Lower wage persistence ($\gamma = 4.0$, $\rho = 0.96$, $\text{corr}(e_{1,1}, e_{2,1}) = 0.5$)			
Total output (GDP)	1.1	1.0	1.4
Labor supply (efficiency units)	0.8	0.7	1.0
Market work hours: men	0.2	0.0	0.4
Market work hours: women	3.6	3.3	3.8
Welfare of age 21 households	0.5	0.9	0.7
4. Higher wage correlation ($\gamma = 4.0$, $\rho = 0.98$, $\text{corr}(e_{1,1}, e_{2,1}) = 1.0$)			
Total output (GDP)	1.0	0.9	1.2
Labor supply (efficiency units)	0.8	0.6	0.9
Market work hours: men	-0.2	-0.3	-0.1
Market work hours: women	4.3	4.1	4.6
Welfare of age 21 households	0.2	0.6	0.3

from the economy with stronger assortative matching. In this baseline economy, the husband's market wage rate and the wife's wage rate at age 21 are perfectly correlated, i.e., the combination of initial wage rates is (e_1^1, e_2^1) , (e_1^2, e_2^2) , ..., or (e_1^5, e_2^5) . However, for simplicity, the Markov transition matrix is unchanged, thus the wage correlation decreases as married couples get older. Under this assumption, the husband's market wage and the wife's wage are relatively close and fewer couples would expect to receive spousal and survivors benefits. By the removal of these benefits, women's

market work hours would increase by 4.1-4.6% from the new baseline economy. The increase rates are 0.2-0.3 percentage points lower than those in the main baseline economy. Total output would increase by 0.9-1.2%. The welfare effects of the policy change in this baseline economy are smaller compared to the main baseline economy.

Overall, the effects of the policy change on female labor supply would depend on the values of several parameters assumed in the model economy. However, the effects on the overall macro economy, as well as the well-being of households, would not be very different across the baseline economies.

6 Concluding Remarks

The present paper extends a standard heterogeneous-agent general-equilibrium OLG model with idiosyncratic wage shocks by implementing the joint decision making of married couples and the OASI spousal and survivors benefit; calibrates the model to the 2009 U.S. economy; and analyzes the possible labor supply, macroeconomic, and welfare effects of removing the survivors and spousal benefits. According to the numerical policy experiments of the model, the removal of those benefits would increase female market work hours significantly by 4.3-4.9% in the long run in the main baseline economy. The policy change would also increase overall labor supply, capital stock, and total output of the economy. Most importantly, the model predicts that removing spousal and survivors benefits could improve the average welfare of all current and future age cohorts if the additional tax revenue due to higher output was reimbursed to the households by lump-sum transfers.

To make the model and the decision making of married couples as simple as possible, the present paper assumes a unitary utility model of married households. That is, a husband and a wife are fully altruistic to each other, and they choose their optimal consumption, working hours, and saving jointly. Also, the paper does not consider the possibilities of divorce and remarrying, because keeping the historical earnings of history of ex spouses would make the general equilib-

rium model computationally intractable. However, the risk of separation would probably affect the labor supply and saving decisions due to precautionary motives. Relaxing these assumptions by introducing imperfect altruism, the strategic interactions between a husband and a wife, and marriage and divorce decisions are left for possible future projects.

Through the policy experiments, the present paper has shown to what extent the removal of spousal and survivors benefits would likely increase the labor supply of married couples and improve the welfare of heterogeneous households. The model developed in this paper would also predict the effects of changes in fiscal policy and technology. The questions the model could answer include how much female labor supply would increase when the wage disparity between men and women is reduced; when private firms change their policy on health insurance coverage; when the government subsidizes the cost of daycare services, and so on. An extended version of the model would also help in designing the optimal benefit schedule of the Social Security OASI program.

A Computational Algorithm

We solve the household's optimization problem recursively from age $i = I$ to age $i = 1$ by discretizing the asset space, $A = [0, a_{\max}]$, into 21 nodes, $\hat{A} = \{a^1, a^2, \dots, a^{21}\}$, the average historical earning space, $B = [0, b_{\max}]$, into 12 nodes each, $\hat{B} = \{b^1, b^2, \dots, b^{12}\}$, and the working ability space, $E = [0, e_{\max}]$, into 5 nodes for a husband and a wife of each age, $\hat{E}_{1,i} = \{e_{1,i}^1, e_{1,i}^2, \dots, e_{1,i}^5\}$ and $\hat{E}_{2,i} = \{e_{2,i}^1, e_{2,i}^2, \dots, e_{2,i}^5\}$.

Let Ω_t be a time series of vectors of factor prices and government policy variables that describes a future path of the aggregate economy,

$$\Omega_t = \{r_s, w_s, C_{G,s}, tr_{LS,s}, \varphi_s, \bar{\tau}_{P,s}, \psi_s, W_{G,s}\}_{s=t}^{\infty}.$$

The household's value function is shown as $v(\mathbf{s}, \mathbf{S}_t; \Psi_t)$, and the factor prices and endogenous government policy variables are shown as $r_s(\mathbf{S}_s; \Psi_s)$, $w_s(\mathbf{S}_s; \Psi_s)$, $\psi_s(\mathbf{S}_s; \Psi_s)$, and so on, for $s \geq t$. However, it is impossible to solve the model of this form because the dimension of $\mathbf{S}_t$ is infinite. In this paper we avoid this curse of dimensionality problem by replacing $(\mathbf{S}_t, \Psi_t)$ with Ω_t . Since we do not assume aggregate shocks in the model economy, the time series Ω_t is deterministic and perfectly foreseeable, thus it will suffice to find the fixed point of Ω_t to solve the model economy for an equilibrium transition path.

In this appendix, we first explain the algorithm to solve the household's optimization problem for each individual state node,

$$\mathbf{s} = (i, a, b_1, b_2, e_1, e_2, m) \in \{1, 2, \dots, I\} \times \hat{A} \times \hat{B}^2 \times \hat{E}_{1,i} \times \hat{E}_{2,i} \times \{0, 1, 2\},$$

taking Ω_t as given. For the numerical methods to solve a Kuhn-Tucker condition for a household's optimal decision, see Judd (1998) and Miranda and Fackler (2002). For a more general algorithm to compute a steady-state equilibrium and an equilibrium transition path, see Nishiyama and Smetters (2007).

A.1 Algorithm to Solve the Household Problem

We solve the household's optimization problem backward from $i = I$ to $i = 1$ by assuming the terminal value $v(\mathbf{s}; \boldsymbol{\Omega}_{t+1})|_{i=I+1} = 0$. The household's problem at age i in period t is modified to

$$v(\mathbf{s}; \boldsymbol{\Omega}_t) = \max_{c, l_1, l_2} \left\{ u(c, l_1, l_2; m) + \tilde{\beta} \phi_{m,i} E[v(\mathbf{s}'; \boldsymbol{\Omega}_{t+1}) | \mathbf{s}] \right\}$$

subject to the constraints for the decision variables,

$$\begin{aligned} 0 < c &\leq c_{\max}, & l_1 &= 1 - h_1, & l_2 &= 1 - h_2, \\ 0 < l_1 &\leq 1 \quad \text{if } m \neq 2, & l_1 &= 1 \quad \text{if } m = 2, \\ 0 < l_2 &\leq 1 \quad \text{if } m \neq 1, & l_2 &= 1 \quad \text{if } m = 1, \end{aligned}$$

and the law of motion of the state variables,

$$\begin{aligned} \mathbf{s}' &= (i + 1, a', b'_1, b'_2, e'_1, e'_2, m'), \\ c_{\max} &= (1 + r_t)a + w_t e_1 h_1 + w_t e_2 h_2 - \tau_{I,t}(r_t a + w_t e_1 h_1 + w_t e_2 h_2; m) \\ &\quad - \tau_{P,t}(w_t e_1 h_1, w_t e_2 h_2) + tr_{SS,t}(i, b_1, b_2, m) + (1 + \mathbf{1}_{\{m=0\}}) tr_{LS,t} - \kappa w_t h_2, \\ a' &= \frac{1}{1 + \mu} (c_{\max} - c), \\ b'_1 &= \mathbf{1}_{\{i < I_R, m \neq 2\}} \frac{1}{i} [(i - 1)b_1 + \min(w_t e_j h_1, \vartheta_{\max})] + \mathbf{1}_{\{i \geq I_R \text{ or } m=2\}} b_1, \\ b'_2 &= \mathbf{1}_{\{i < I_R, m \neq 1\}} \frac{1}{i} [(i - 1)b_2 + \min(w_t e_j h_2, \vartheta_{\max})] + \mathbf{1}_{\{i \geq I_R \text{ or } m=1\}} b_2. \end{aligned}$$

Let the objective function be

$$f(c, l_1, l_2; \mathbf{s}, \boldsymbol{\Omega}_t) = u(c, l_1, l_2; m) + \tilde{\beta} \phi_{m,i} E[v(\mathbf{s}'; \boldsymbol{\Omega}_{t+1}) | \mathbf{s}].$$

Then, the first-order conditions for an interior solution are

$$(18) \quad f_1(c, l_1, l_2; \mathbf{s}, \boldsymbol{\Omega}_t) = u_1(c, l_1, l_2; m) - \frac{\tilde{\beta}\phi_{m,i}}{1+\mu} E[v_a(\mathbf{s}'; \boldsymbol{\Omega}_{t+1}) | \mathbf{s}] = 0,$$

$$(19) \quad f_2(c, l_1, l_2; \mathbf{s}, \boldsymbol{\Omega}_t) = u_2(c, l_1, l_2; m) \\ - w_t e_1 \left[1 - \tau'_{I,t}(r_t a + w_t e_1 h_1 + w_t e_2 h_2; m) - \tau_{P,1,t}(w_t e_1 h_1, w_t e_2 h_2) \right] u_1(c, l_1, l_2; m) \\ - \mathbf{1}_{\{i < I_R, w_t e_1 h_1 < \vartheta_{\max}\}} \frac{w_t e_1}{i} \tilde{\beta}\phi_{m,i} E[v_{b_1}(\mathbf{s}'; \boldsymbol{\Omega}_{t+1}) | \mathbf{s}] = 0,$$

$$(20) \quad f_3(c, l_1, l_2; \mathbf{s}, \boldsymbol{\Omega}_t) = u_3(c, l_1, l_2; m) \\ - w_t e_2 \left[1 - \tau'_{I,t}(r_t a + w_t e_1 h_1 + w_t e_2 h_2; m) - \tau_{P,2,t}(w_t e_1 h_1, w_t e_2 h_2) \right] u_1(c, l_1, l_2; m) \\ - \mathbf{1}_{\{i < I_R, w_t e_2 h_2 < \vartheta_{\max}\}} \frac{w_t e_2}{i} \tilde{\beta}\phi_{m,i} E[v_{b_2}(\mathbf{s}'; \boldsymbol{\Omega}_{t+1}) | \mathbf{s}] = 0,$$

where $\tau'_{I,t}(r_t a + w_t e_1 h_1 + w_t e_2 h_2; m)$ is the marginal income tax rate and $\tau_{P,k,t}(w_t e_1 h_1, w_t e_2 h_2)$ is the marginal payroll tax rate, corresponding to the k th argument. Equation (18) is the Euler equation, and equations (19) and (20) are the marginal rate of substitution conditions of consumption for leisure.

With the inequality constraints for the decision variables, the Kuhn-Tucker conditions of the household's problem are expressed as the following nonlinear complementarity problem,

$$\begin{aligned} f_1(c, l_1, l_2; \mathbf{s}, \boldsymbol{\Omega}_t) &= 0 \quad \text{if} \quad 0 < c < c_{\max}, & > 0 \quad \text{if} \quad c = c_{\max}, \\ f_2(c, l_1, l_2; \mathbf{s}, \boldsymbol{\Omega}_t) &= 0 \quad \text{if} \quad 0 < l_1 < 1, & > 0 \quad \text{if} \quad l_1 = 1, \\ f_3(c, l_1, l_2; \mathbf{s}, \boldsymbol{\Omega}_t) &= 0 \quad \text{if} \quad 0 < l_2 < 1, & > 0 \quad \text{if} \quad l_2 = 1, \end{aligned}$$

which is expressed more compactly as the nonlinear system of equations,

$$(21) \quad \min \left\{ \max \left[\begin{pmatrix} f_1(c, l_1, l_2; \mathbf{s}, \boldsymbol{\Omega}_t) \\ f_2(c, l_1, l_2; \mathbf{s}, \boldsymbol{\Omega}_t) \\ f_3(c, l_1, l_2; \mathbf{s}, \boldsymbol{\Omega}_t) \end{pmatrix}, \begin{pmatrix} \varepsilon - c \\ \varepsilon - l_1 \\ \varepsilon - l_2 \end{pmatrix} \right], \begin{pmatrix} c_{\max} - c \\ 1 - l_1 \\ 1 - l_2 \end{pmatrix} \right\} = \mathbf{0},$$

where ε is a small positive number. Following Miranda and Fackler (2002), we replace the $\min(u, v)$ and $\max(u, v)$ operators with

$$\phi^-(u, v) \equiv u + v - \sqrt{u^2 + v^2}, \quad \phi^+(u, v) \equiv u + v + \sqrt{u^2 + v^2},$$

respectively, to make the above system of equations differentiable without altering the solutions. We solve equation (21) for $c(\mathbf{s}; \boldsymbol{\Omega}_t)$, $l_1(\mathbf{s}; \boldsymbol{\Omega}_t)$, and $l_2(\mathbf{s}; \boldsymbol{\Omega}_t)$ by using a Newton-type nonlinear equation solver, NEQNF, of the IMSL Fortran Numerical Library.¹⁴

Once we obtain the optimal decision, we next calculate the value of the household with state $\mathbf{s}$ in period t as

$$(22) \quad v(\mathbf{s}; \boldsymbol{\Omega}_t) = u(c(\mathbf{s}; \boldsymbol{\Omega}_t), l_1(\mathbf{s}; \boldsymbol{\Omega}_t), l_2(\mathbf{s}; \boldsymbol{\Omega}_t); m) + \tilde{\beta} \phi_{m,i} E[v(\mathbf{s}'; \boldsymbol{\Omega}_{t+1}) | \mathbf{s}],$$

and the corresponding marginal values as

$$(23) \quad v_a(\mathbf{s}; \boldsymbol{\Omega}_t) = [1 + r_t(1 - \tau'_{I,t}(r_t a + w_t e_1 h_1(\mathbf{s}; \boldsymbol{\Omega}_t) + w_t e_2 h_2(\mathbf{s}; \boldsymbol{\Omega}_t)); m)] \\ \times u_c(c(\mathbf{s}; \boldsymbol{\Omega}_t), l_1(\mathbf{s}; \boldsymbol{\Omega}_t), l_2(\mathbf{s}; \boldsymbol{\Omega}_t); m),$$

$$(24) \quad v_{b_1}(\mathbf{s}; \boldsymbol{\Omega}_t) = tr_{SS,b_1,t}(i, b_1, b_2, m) u_c(c(\mathbf{s}; \boldsymbol{\Omega}_t), l_1(\mathbf{s}; \boldsymbol{\Omega}_t), l_2(\mathbf{s}; \boldsymbol{\Omega}_t); m) \\ + \left(\mathbf{1}_{\{i < I_R, m \neq 2\}} \frac{i-1}{i} + \mathbf{1}_{\{i \geq I_R \text{ or } m=2\}} \right) \tilde{\beta} \phi_{m,i} E[v_{b_1}(\mathbf{s}'; \boldsymbol{\Omega}_{t+1}) | \mathbf{s}],$$

$$(25) \quad v_{b_2}(\mathbf{s}; \boldsymbol{\Omega}_t) = tr_{SS,b_2,t}(i, b_1, b_2, m) u_c(c(\mathbf{s}; \boldsymbol{\Omega}_t), l_1(\mathbf{s}; \boldsymbol{\Omega}_t), l_2(\mathbf{s}; \boldsymbol{\Omega}_t); m) \\ + \left(\mathbf{1}_{\{i < I_R, m \neq 1\}} \frac{i-1}{i} + \mathbf{1}_{\{i \geq I_R \text{ or } m=1\}} \right) \tilde{\beta} \phi_{m,i} E[v_{b_2}(\mathbf{s}'; \boldsymbol{\Omega}_{t+1}) | \mathbf{s}],$$

where $tr_{SS,b_1,t}(i, b_1, b_2, m)$ and $tr_{SS,b_2,t}(i, b_1, b_2, m)$ are the marginal OASI benefits corresponding to b_1 and b_2 , respectively. These marginal values are used to solve the optimization problem of age $i-1$ in period $t-1$. The marginal benefit functions in the baseline economy are obtained as

$$tr_{SS,b_1,t}(i, b_1, b_2, m)$$

¹⁴NEQNF uses a modified Powell hybrid algorithm and a finite-difference approximation to the Jacobian.

$$\begin{aligned}
&= \begin{cases} \psi_t \left[\mathbf{1}_{\{\psi(i,b_1) \geq 0.5\psi(i,b_2)\}} \psi_b(i, b_1) + \mathbf{1}_{\{\psi(i,b_1) > 2.0\psi(i,b_2)\}} 0.5\psi_b(i, b_1) \right] & \text{if } m = 0, \\ \psi_t \mathbf{1}_{\{\psi(i,b_1) \geq \psi(i,b_2)\}} \psi_b(i, b_1) & \text{if } m = 1, 2, \end{cases} \\
tr_{SS,b_2,t}(i, b_1, b_2, m) \\
&= \begin{cases} \psi_t \left[\mathbf{1}_{\{\psi(i,b_2) \geq 0.5\psi(i,b_1)\}} \psi_b(i, b_2) + \mathbf{1}_{\{\psi(i,b_2) > 2.0\psi(i,b_1)\}} 0.5\psi_b(i, b_2) \right] & \text{if } m = 0, \\ \psi_t \mathbf{1}_{\{\psi(i,b_2) \geq \psi(i,b_1)\}} \psi_b(i, b_2) & \text{if } m = 1, 2, \end{cases}
\end{aligned}$$

where $\psi_b(i, b_j)$ is the marginal primary insurance amount (PIA) function,

$$\psi_b(i, b_j) = \mathbf{1}_{\{i \geq I_R\}} (1 + \mu)^{40-i} \{ \mathbf{1}_{\{b_j < \vartheta_1\}} 0.90 + \mathbf{1}_{\{\vartheta_1 \leq b_j < \vartheta_2\}} 0.32 + \mathbf{1}_{\{\vartheta_2 \leq b_j\}} 0.15 \}$$

for $j = 1$ and 2 . The marginal benefit functions in the economy without spousal and survivors benefits are

$$\begin{aligned}
tr_{SS,b_1,t}^1(i, b_1, b_2, m) &= \psi_t \psi_b(i, b_1) & \text{if } m = 0 \text{ or } 1, & & = 0 & \text{if } m = 2, \\
tr_{SS,b_2,t}^1(i, b_1, b_2, m) &= \psi_t \psi_b(i, b_2) & \text{if } m = 0 \text{ or } 2, & & = 0 & \text{if } m = 1.
\end{aligned}$$

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