The Joint Decision-Making of Married Couples and the Social Security Pension System*

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Abstract

The current OASI program redistributes resource 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 assumes “unisex” individuals and does not consider the redistribution between one-earner and two-earner households. In the present paper, we extend a standard general equilibrium OLG model with heterogeneous agents and quantitatively analyze the effect of spousal and survivors benefits on the labor supply of married couples. According to our model, calibrated to the 2009 U.S. economy, removing spousal and survivors benefits would increase female market work hours by 3.1-3.6% and total output by 0.9-1.4% in the long run. A phased-in removal of these benefits could make all current and future age cohorts on average better off if the increased tax revenue due to the output increase was appropriately reimbursed.

JEL Classification Numbers: D91, E62, H55.

Key Words: dynamic general equilibrium; heterogeneous agents; overlapping generations; female labor supply.

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1 Introduction

The current Old-Age and Survivors Insurance (OASI) program in the U.S. redistributes resource from high wage workers to low wage workers and from two-earner couples to one-earner couples. However, the previous literature on the dynamic general equilibrium analyses of Social Security reform mostly assumes “unisex” individuals and does not consider the wealth redistribution between one-earner and two-earner households.\(^1\) The absence of spousal and survivors benefits in the model potentially underestimates the labor supply distortion due to the OASI payroll tax, because 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 earner’s labor supply is in general much higher.

In the present paper, we extend a standard dynamic general equilibrium overlapping-generations (OLG) model with heterogeneous households and incomplete markets by implementing the joint decision-making of married couples. Then, we calibrate the model to the U.S. economy and analyze 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 economic efficiency and social welfare without significantly reducing the insurance aspect of the Social Security program.

In our model economy, households are heterogeneous with respect to their marital status (married, widowed, or widowered), 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.\(^2\) In each period, which is a year, a household receives idiosyncratic market wage shocks (one for the husband and another for the wife) and jointly choose their 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.


\(^2\)For simplicity, we abstract from modeling the opportunity cost of raising children. Thus, as we will show the result later, female labor supply in our model economy is larger than that in the U.S. economy.
We first construct a baseline economy, which is on the balanced growth path, with the current OASI system with spousal and survivors benefits, and we check whether the model economy matches the U.S. economy in terms of the distribution of the OASI benefits by type—worker’s own benefits, spousal benefits, and survivors benefits received by widow(er)s. Then, we introduce a phased-in (cohort-by-cohort) removal of spousal and survivors benefits and solve the model for both steady states and equilibrium transition paths under several different financing assumptions. Regarding the OASI budget, we assume that it is separated from the rest of the government budget and that worker’s own benefits are increased proportionally by keeping the payroll tax rate at the same level.

The main findings of this paper are as follows: By removing spousal and survivors benefits from the current OASI system, the market work hours of women would increase by 3.1-3.6%, depending on the government financing assumption, in the long run. The policy effect is in general largest if the government cuts the marginal income tax rates and smallest if it increases transfer spending instead to balance the budget. The market work hours of men would increase only by 0.0-0.4%. Total labor supply in efficiency units would increase by 0.7-1.1% and total output (GDP) would also increase by 0.9-1.4% in the long run.

If the additional tax revenue due to the policy change were redistributed (reimbursed) to households by either increasing lump-sum transfers or reducing marginal income tax rates, the removal of spousal and survivors benefits would improve the average welfare level of newborn households both in the long run and in the short run. Thus, although there are some households (more specifically, households with high market wage husband and low wage wife) would be worse off to some extent, all age cohorts would be on average better off by the policy change.\(^3\)

To the best of our knowledge, this is the probably the first attempt to analyze the effect of spousal and survivors benefits by using a large-scale dynamic general equilibrium OLG model. However, the present paper is indebted to many previous papers on female labor supply, Social Security reform, and life insurance and annuities.

\(^3\)Since husbands in households that would suffer from the policy change have high market wage, the welfare loss of these households would be relatively modest.
Olivetti (2006) construct 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 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, our model assumes unitary households—perfectly altruistic married couples—similar to the above papers. We abstract from modeling the home production and cost of childcare and human capital accumulation, but we focus more on household’s reaction to the current OASI policy.\(^4\)

[TO BE COMPLETED.]

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 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.

\(^4\)The current OASI system calculates the worker’s primary insurance amounts (PIA) by using the average indexed monthly earnings (AIME) calculated from the highest 35 years of OASI taxable earnings. Thus, being away from labor market for 5 to 10 years for childcare at home will not necessarily and significantly reduce women’s own OASI benefits.
2.1 The Households

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

The model age \( i = 1 \) is corresponding to the real age 21. For simplicity, the husband and the wife are of 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 to approximate the average indexed monthly earnings (AIMEs) and determine the primary insurance amounts (PIAs) of Social Security pension. The working abilities of the husband and wife follow the first-order Markov process, and these are independent from each other and independent of the mortality shocks.

In each year, \( t \), a household receives working 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.\(^5\) The OASI benefits (PIAs) of each household are calculated separately for the husband and the wife. Yet, for the pension benefits of the secondary earner, the household chooses either the worker’s own old-age benefit or the spousal benefit whichever is higher.

**State Variables.** Let \( s \) and \( S_t \) be the individual state of a household and the aggregate state of the economy in year \( t \), respectively,

\[
  s = (i, a, b_1, b_2, e_1, e_2, m), \quad S_t = (x(s), W_{G,t}),
\]

\(^5\)We abstract from modeling home production. Thus, the household’s utility from leisure, \( 1 - h_1 \) and \( 1 - h_2 \), is assumed to include any utility from consuming home-produced goods and services.
where \( x(s) \) is the population density function of households and \( W_{G,t} \) is the government net wealth at the beginning of year \( t \), and let \( \Psi_t \) be the government policy schedule as of year \( t \),

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

where \( C_{G,t} \) is government consumption, \( tr_{LS,t} \) is a lump sum transfer 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 next year.

**The Optimization Problem.** Let \( v(s, S_t; \Psi_t) \) be the value function of a heterogeneous household at the beginning of year \( t \). Then, the household’s optimization problem is

\[
(1) \quad v(s, S_t; \Psi_t) = \max_{c, h_1, h_2} \left\{ u(c, 1 - h_1, 1 - h_2; m) + \beta \phi_{m,i} \sum_{m'=0}^2 \int_{E^2} v(s', S_{t+1}; \Psi_{t+1}) d\Pi_i(e'_1, e'_2, m'| e_1, e_2, m) \right\}
\]

subject to the constraints for the decision variables,

\[
(2) \quad c > 0,
\]

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

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

and the law of motion of the individual state,

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

\[
(6) \quad a' = \frac{1}{(1 + \mu)\phi_{m,i}} \left[ (1 + r_i)a + w_i e_1 h_1 + w_i e_2 h_2 - \tau_{I,t}(r_i a + w_i e_1 h_1 + w_i e_2 h_2; m) - \tau_{P,t}(w_i e_1 h_1, w_i e_2 h_2) + tr_{SS,t}(i, b_1, b_2, m) + (1 + 1_{m=0}) tr_{LS,t} - c \right] \geq 0,
\]
(7) \[ b_j = \mathbf{1}_{\{i < I_R\}} \frac{1}{I} \left[ (i - 1)b_j + \min(\vartheta_0 w_t e_j h_j, \vartheta_{\text{max}}) \right] + \mathbf{1}_{\{i \geq I_R\}} b_j \quad \text{for } j = 1, 2, \]

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, \( \mu \) is the long-run productivity growth rate, \( r_t \) is the interest rate, \( w_t \) is the wage rate per efficiency unit of labor, \( \tau_{I,t}(\cdot) \) is the individual income tax function, \( \tau_{P,t}(\cdot) \) is the payroll tax function for social security with maximum taxable earnings \( \vartheta_{\text{max}} \), \( \tau_{SS,t}(\cdot) \) is the social security benefit function, and \( 1_{\{\cdot\}} \) is an indicator function that returns 1 if the condition in \( \{ \} \) holds and 0 otherwise. 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, \( 1 + \mu \). The average historical earnings, \( b_j \), is a proxy of the average indexed monthly earnings (AIME) times 12. However, the AIME is calculated by using the highest 35 years of OASI taxable earnings instead of the average of whole earnings. Thus, we adjust the earnings by an adjustment factor, \( \vartheta_0 > 1 \).

**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,

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

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

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

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 \( \lambda = 1 \).\(^6\) With

\(^6\)The 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, \( \tilde{u}_1(c_1, c_2, 1 - h_1, 1 - h_2) = \tilde{u}_1(c_1, 1 - h_1) + \tilde{u}_2(c_2, 1 - h_2) = \tilde{u}_1(c_1, 1 - h_1) + \tilde{u}_2(c_2, 1 - h_2) \).
this specification, the growth-adjusted time discount factor is calculated as \( \tilde{\beta} = \beta(1 + \mu)^{\alpha(1-\gamma)} \) when \( \beta \) is the unadjusted time discount factor.

**Partial Annuitization.** We do not assume any intentional bequest motives to the next generation for simplicity. Thus, the household purchases annuities at an actuarially-fair price, \( \phi_{m,i} \), to protect itself from a risk that it will live too long. Let \( \phi_{1,i} \) and \( \phi_{2,i} \) be the survival rates of the husband and the wife, respectively. Then, when both the husband and the wife are alive (\( m = 0 \)) at the beginning of age \( i \), the probability that at least one of them survives at the end of age \( i \) is \( \phi_{0,i} = 1 - (1 - \phi_{1,i})(1 - \phi_{2,i}) \).

**The State Transition Function.** We assume that the husband’s working ability and the wife’s working ability are independent of each other and independent of the mortality of their spouses, that the deaths of the husband and wife are independent. 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

\[
\begin{align*}
p_{m,i}(0 | 0) &= \phi_{1,i}\phi_{2,i}, & p_{m,i}(1 | 0) &= \phi_{1,i}(1 - \phi_{2,i}), & p_{m,i}(2 | 0) &= (1 - \phi_{1,i})\phi_{2,i}, \\
p_{m,i}(0 | 1) &= 0, & p_{m,i}(1 | 1) &= \phi_{1,i}, & p_{m,i}(2 | 1) &= 0, \\
p_{m,i}(0 | 2) &= 0, & p_{m,i}(1 | 2) &= 0, & p_{m,i}(2 | 2) &= \phi_{2,i}.
\end{align*}
\]

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Given \( h_1 \) and \( u_2(c_2, 1-h_2) \) and \( u_2(c_2, c_1, 1-h_2, 1-h_1) \), where \( \varphi \leq 1 \) is the degree of altruism. In the present paper, we assume that a married couple are perfectly altruistic, \( \varphi = 1 \), and that their consumption are 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.
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),

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

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 $\vartheta_1$ and $\vartheta_2$ 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, PIA’s of the husband and the wife, $\psi(i, b_1)$ and $\psi(i, b_2)$, are

$$\psi(i, b_j) = 1_{\{i \geq t_R\}} (1 + \mu)^{40-i} \left\{ 0.90 \min(b_j, \vartheta_1) + 0.32 \max[\min(b_j, \vartheta_2) - \vartheta_1, 0] + 0.15 \max(b_j - \vartheta_2, 0) \right\} \text{ for } j = 1, 2,$$
and the current-law OASI benefit function is

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

where \(\psi_t\) is an OASI benefit adjustment factor. 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, \(c(s, S_t; \Psi_t)\), \(h_1(s, S_t; \Psi_t)\), and \(h_2(s, S_t; \Psi_t)\). The other decision rules are also obtained as

\[
a'(s, S_t; \Psi_t) = \frac{1}{(1 + \mu)\phi_m, t} [(1 + \tau_t)a + w_t e_1 h_1(s, S_t; \Psi_t) + w_t e_2 h_2(s, S_t; \Psi_t)
- \tau_{t, t}(r_t a + w_t e_1 h_1(s, S_t; \Psi_t) + w_t e_2 h_2(s, S_t; \Psi_t); m)
- \tau_{P, t}(w_t e_1 h_1(s, S_t; \Psi_t), w_t e_2 h_2(s, S_t; \Psi_t)) + tr_{SS,t}(i, b_1, b_2, m)
+ (1 + 1_{\{m=0\}})tr_{LS,t} - c(s, S_t; \Psi_t)] \geq 0,
\]

\[
b'_j(s, S_t; \Psi_t) = 1_{\{i < I_R\}} \frac{1}{i} [(i - 1)b_j + \min(\vartheta_0 w_t e_j h_j(s, S_t; \Psi_t), \vartheta_{\max})] + 1_{\{i \geq I_R\}} b_j
\]

for \(j = 1, 2\).

**The Distribution of Households.** Let \(x_i(s)\) be the growth-adjusted population density of households in period \(t\), and let \(X_i(s)\) 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

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7We discretize the individual state space and solve the Kuhn-Tucker conditions of the household problem by a Newton-type nonlinear equation solver for each state. See Appendix for the computational algorithm used to solve the problem.
normalized to unity,
\[
\sum_{m=0}^{2} \int_{A \times B^2 \times E^2} dX_t(1, a, b_1, b_2, e_1, e_2, m) = \int_{E^2} dX_t(1, 0, 0, e_1, e_2, 0) = 1.
\]

Let \( \nu \) be the time-invariant population growth rate. Then, the law of motion of the growth-adjusted population distribution is
\[
x_{t+1}(s') = \frac{1}{1 + \nu} \sum_{m=0}^{2} \int_{A \times B^2 \times E^2} 1\{a' = a'(s, S_t; \Psi_t), b'_1 = b'_1(s, S_t; \Psi_t), b'_2 = b'_2(s, S_t; \Psi_t)\} 
\times \pi_i(e'_1, e'_2, m' | e_1, e_2, m) dX_t(s),
\]
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
\[
W_{P,t} = \sum_{i=1}^{I} \sum_{m=0}^{2} \int_{A \times B^2 \times E^2} a dX_t(s),
\]
\[
K_t = W_{P,t} + W_O + W_{G,t},
\]
\[
L_t = \sum_{i=1}^{I} \sum_{m=0}^{2} \int_{A \times B^2 \times E^2} (e_1 h_1(s, S_t; \Psi_t) + e_2 h_2(s, S_t; \Psi_t)) dX_t(s),
\]
where \( W_O \) denotes private wealth that is not explained by the life-cycle saving motive.

### 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, \( i.e., \)
\[
\max_{\tilde{K}_t, \tilde{L}_t} F(\tilde{K}_t, \tilde{L}_t) - (r_t + \delta) \tilde{K}_t - w_t \tilde{L}_t,
\]
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 $\delta$ is the depreciation rate of capital. The profit maximizing conditions are

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

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

### 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.\(^8\) The government’s social security payroll tax revenue, $T_{P,t}$, is

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

the social security benefit expenditure, $TR_{SS,t}$, is

$$TR_{SS,t}(\psi_t) = \sum_{i=1}^{I_R} \sum_{m=0}^{2} \int_{A \times B^2 \times E^2} tr_{SS,t}(i, b_1, b_2; \psi_t) dX_t(s),$$

and the parameter, $\psi_t$, of the benefit function is adjusted so that the benefit expenditure is equal to the payroll tax revenue, i.e., $TR_{SS,t}(\psi_t) = T_{P,t}(\bar{\tau}_{P,t})$.

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\(^8\)If 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

\[ T_{I,t}(\varphi_t) = \sum_{i=1}^{I} \sum_{m=0}^{2} \int_{A \times B^2 \times E^2} \tau_{I,t}(r_t + w_t e_1 h_1(s, S_t; \Psi_t) + w_t e_2 h_2(s, S_t; \Psi_t); m, \varphi_t) dX_t(s), \]

the aggregate lump-sum transfer expenditure is

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

and the law of motion of government wealth is

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

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.

### 2.4 Recursive Competitive Equilibrium

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

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

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

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

\[ \Omega_t = \{r_s, w_s, C_{G,s}, tr_{LS,s}, \varphi_s, \bar{\tau}_{P,s}, \bar{\psi}_s, W_{G,s}\}_{s=t}^{\infty}. \]
where $\varphi_t$ is a parameter of the individual income tax function, $\bar{\tau}_{P,t}$ is a parameter of the payroll tax function, and $\psi_t$ is a parameter of the Social Security benefit function; the value functions of households, $\{v(s, S_s; \Psi_s)\}_{s=t}^{\infty}$, the decision rules of households,

$$\{d(s, S_s; \Psi_s)\}_{s=t}^{\infty} = \{c(s, S_s; \Psi_s), h_1(s, S_s; \Psi_s), h_2(s, S_s; \Psi_s), \alpha'(s, S_s; \Psi_s)\}_{s=t}^{\infty},$$

and the distribution of households, $\{x_s(s)\}_{s=t}^{\infty}$, are in a recursive competitive equilibrium if, for all $s = t, \ldots, \infty$, each household solves the optimization problem (1)-(7), taking $S_s$ and $\Psi_s$ as given; the firm solves its profit maximization problem (8)-(9); the government policy schedule satisfies (10)-(14); and the goods and factor markets clear. The economy is in a steady-state equilibrium thus on a balanced growth path if, in addition, $S_s = S_{s+1}$ and $\Psi_{s+1} = \Psi_s$ for all $s = t, \ldots, \infty$.

### 3 Calibration

Table 1 shows the main parameters and policy variables in the baseline economy. The baseline economy is on the balanced-growth path with the current-law OASI system.

#### 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 total population in the United States. For simplicity, 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, $\mu$, is 0.018 and the population growth rate, 0.01, in the model economy. These numbers are consistent with the 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. The transition matrix of the marital status, $\Pi_{m,i} = [p(m'|m)]$
Table 1: Main Parameters and Policy Variables in the Baseline Economy

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum possible age</td>
<td>80</td>
<td>Real age 100</td>
</tr>
<tr>
<td>Retirement age</td>
<td>46</td>
<td>Full retirement age 66</td>
</tr>
<tr>
<td>Productivity growth rate</td>
<td>0.018</td>
<td></td>
</tr>
<tr>
<td>Population growth rate</td>
<td>0.010</td>
<td></td>
</tr>
<tr>
<td>Share parameter of consumption</td>
<td>0.36</td>
<td>Cooley et al. (1995)</td>
</tr>
<tr>
<td>Coefficient of relative risk aversion</td>
<td>4.0</td>
<td>Auerbach et al. (1987)</td>
</tr>
<tr>
<td>Adjustment parameter of consumption</td>
<td>0.60</td>
<td>Bernheim et al. (2008)</td>
</tr>
<tr>
<td>Share parameter of capital stock</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Depreciation rate of capital stock</td>
<td>0.0611</td>
<td></td>
</tr>
<tr>
<td>Total factor productivity</td>
<td>0.9528</td>
<td></td>
</tr>
<tr>
<td>Average median wage: men aged 21-65</td>
<td>$1.0</td>
<td>$44,200 in 2009*1</td>
</tr>
<tr>
<td>Auto correlation parameter of log wage</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>Standard deviation of wage shocks: men</td>
<td>0.1831</td>
<td>$0.586</td>
</tr>
<tr>
<td>Income tax parameters: tax rate limit</td>
<td>0.35</td>
<td>2009 tax rate schedules</td>
</tr>
<tr>
<td>married (m = 0)</td>
<td>0.9601</td>
<td>Estimated by OLS</td>
</tr>
<tr>
<td>: scale</td>
<td>1.0626</td>
<td></td>
</tr>
<tr>
<td>: deduction/exemptions</td>
<td>0.1523</td>
<td>$2 \times 3,650 + 11,400 in 2009</td>
</tr>
<tr>
<td>single (m = 1, 2)</td>
<td>0.7494</td>
<td>Estimated by OLS</td>
</tr>
<tr>
<td>: scale</td>
<td>1.2144</td>
<td></td>
</tr>
<tr>
<td>: deduction/exemptions</td>
<td>0.0762</td>
<td>$3,650 + 5,750 in 2009</td>
</tr>
<tr>
<td>Social Security payroll tax rate</td>
<td>0.106</td>
<td>OASI tax rate 0.053 \times 2</td>
</tr>
<tr>
<td>Maximum taxable earnings</td>
<td>0.8699</td>
<td>$106,800 in 2009</td>
</tr>
<tr>
<td>AIME adjustment factor</td>
<td>1.12</td>
<td>Monte Carlo simulation</td>
</tr>
<tr>
<td>Replacement rate threshold: 0.90 &amp; 0.32</td>
<td>0.0727</td>
<td>$744 \times 12 = 8,928 in 2009</td>
</tr>
<tr>
<td>: 0.32 &amp; 0.15</td>
<td>0.4382</td>
<td>$4,483 \times 12 = 53,796 in 2009</td>
</tr>
<tr>
<td>Time discount factor</td>
<td>1.0008</td>
<td>$K/Y = 2.7$ and $W_P/Y = 1.8$</td>
</tr>
<tr>
<td>Growth-adjusted time discount factor</td>
<td>0.9817</td>
<td>$\bar{\beta} = \beta(1 + \mu)^{\alpha(1-\gamma)}$</td>
</tr>
<tr>
<td>Government consumption</td>
<td>4.0428</td>
<td>$C_{G,t} = T_{I,t}$</td>
</tr>
<tr>
<td>Lump-sum transfers</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Government net wealth</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>OASI benefit adjustment factor</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>OASI residual (legacy and other costs)</td>
<td>0.3558</td>
<td>$TR_O = T_P,0 - TR_{SS,0}$</td>
</tr>
</tbody>
</table>

*1 The population average of the estimated median earnings of full-time male workers by age. A unit in the model economy thus corresponds to $122,778 in 2009.
for $i < I - 1$, is

$$\Pi_{m,i} = \begin{pmatrix} \phi_{1,i} & \phi_{1,i}(1-\phi_{2,i}) & (1-\phi_{1,i})\phi_{2,i} \\ 0 & \phi_{1,i} & 0 \\ 0 & 0 & \phi_{2,i} \end{pmatrix}.$$ 

3.2 Preference and Technology Parameters

The share parameter of consumption in the utility function, $\alpha$, is set at 0.36, following the real business cycle (RBC) literature (for example, Cooley and Prescott, 1995). The coefficient of relative risk aversion, $\gamma$, is 4.0 in the model economy, following Auerbach and Kotlikoff (1987) and Conesa, Kitao, Krueger (2009). With these parameter values, the elasticity of substitution of the husband’s market work hours for the wife’s is approximately $\frac{1-\alpha}{\alpha(1-\alpha)(1-\gamma)-1} = 0.61$. The consumption adjustment factor for a married couple, $\lambda$ is assumed to be 0.6, following Bernheim, Forni, Gokhale, and Kotlikoff (2003).

The share parameter of capital stock in the production function, $\theta$, is set at 3.0, which is close to the recent U.S. data. The depreciation rate of capital stock, $\delta$, is set at $0.061\dot{1}$ so that the interest rate, $r$, is equal to 0.05 in the baseline economy when the capital-GDP ratio is 2.7. Total factor productivity, $A$, is set at 0.9528 so that the average wage rate, $w$, is normalized to unity in the baseline. The population-weighted average of the median male wage rate, $w\bar{e}_1$, for ages 21-65 ($i = 1, \ldots, I_R - 1$) is also normalized to unity.

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

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

\footnote{Attanasio, 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 our policy experiments.}
Figure 1: The Earnings Profile of Men and Women (Median usual weekly earnings of full-time wage and salary workers, 2009)

for $i = 1, \ldots, I_R - 1$ and $j = 1, 2$, where $e_{j,i}$ 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 $\epsilon_{j,i} \sim N(0, \sigma_j^2)$ and $\ln z_{j,0} \sim N(0, \sigma_j^2/(1 - \rho^2))$. We construct the median market wage rates of men and women, $\bar{e}_{1,i}$ and $\bar{e}_{2,i}$, for ages between 21 and 65 by using 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). Because the median earnings in the table are summarized by 5 or 10-year age groups, we interpolate the median earnings profiles by population-weighted OLS for ages 21-70. Figure 1 shows the original data and estimated values. We assume that the full-time working hours in the model economy is $\alpha = 0.36$. Then, 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, $\$44,200 = \$850 \times 52$, calculated from Table 1 in the U.S. Bureau of Labor Statistics (2010).

The autocorrelation parameter, $\rho$, is assumed to be 0.95. Then, the standard deviations, $\sigma_1$ and
\( \sigma_2 \), are set at 0.1831 and 0.1724 by the following calculation. We use the quintiles and selected deciles of 2009 weekly earnings of full-time wage and salary workers in the Current Population survey (Table 6 in U.S. Bureau of Labor Statistics, 2010) and fit the log-normal distribution for men and women. The estimated unconditional standard deviations of log wages of men and women are
\[ \sigma[\ln e_1] = 0.623 \] and
\[ \sigma[\ln e_2] = 0.567. \]

Then, the conditional standard deviations of log wages of men and women for each age are
\[
\sigma[\ln e_{1,i} | i] = \sqrt{\sigma^2[\ln e_1] - \sigma^2[\ln \bar{e}_{1,i}]} = \sqrt{0.6233^2 - 0.2111^2} = 0.5865, \\
\sigma[\ln e_{2,i} | i] = \sqrt{\sigma^2[\ln e_2] - \sigma^2[\ln \bar{e}_{2,i}]} = \sqrt{0.5669^2 - 0.1287^2} = 0.5520.
\]

Finally, when \( \rho = 0.95 \), the standard deviations of \( \epsilon_1 \) and \( \epsilon_1 \) are obtained as
\[
\sigma_1 = \sqrt{1 - \rho^2} \sigma[\ln e_{1,i} | i] = 0.1831, \\
\sigma_2 = \sqrt{1 - \rho^2} \sigma[\ln e_{2,i} | i] = 0.1724.
\]

We discretize the log persistent shocks, \( \ln z_{1,i} \) and \( \ln z_{2,i} \), into 11 levels each by using Gauss-Hermite quadrature nodes with \( \sigma[\ln z_{1,i}] = 0.5865 \), and \( \sigma[\ln z_{2,i}] = 0.5520 \); then generate 5 levels of \( \ln z_{1,i} \) and \( \ln z_{2,i} \) by combining 4 nodes in each tail distribution into one node.\(^\text{10}\) We combine the tail nodes because matching the tail distributions of wage rates is less important for the present paper. Table 2 shows the five nodes of the persistent wage shocks of men and women as well as unconditional distribution of these nodes. The Markov transition matrix, \( \Pi_{e_1,i} = [\pi(e_{k+1,i+1} \mid e_{i,i})] \) and \( \Pi_{e_2,i} = [\pi(e_{k+1,i} \mid e_{2,i})] \) for \( i < I_R - 1 \), that corresponds to \( \rho = 0.95 \) are calculated by using the bivariate normal distribution function, and it is
\[
\Pi_{e_1,i} = \Pi_{e_2,i} = \begin{pmatrix}
0.8979 & 0.1021 & 0.0000 & 0.0000 & 0.0000 \\
0.0308 & 0.8902 & 0.0790 & 0.0000 & 0.0000 \\
0.0000 & 0.0518 & 0.8964 & 0.0518 & 0.0000 \\
0.0000 & 0.0000 & 0.0790 & 0.8902 & 0.0308 \\
0.0000 & 0.0000 & 0.0000 & 0.1021 & 0.8979
\end{pmatrix}.
\]

\(^{10}\)See, for example, Judd (1998) for general calculation of Gauss-Hermite quadrature.
Table 2: Five Levels of the Persistent Wage Shocks

<table>
<thead>
<tr>
<th></th>
<th>$e^1$</th>
<th>$e^2$</th>
<th>$e^3$</th>
<th>$e^4$</th>
<th>$e^5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$z_{1,i}$</td>
<td>0.3103</td>
<td>0.5801</td>
<td>1.0000</td>
<td>1.7240</td>
<td>3.2229</td>
</tr>
<tr>
<td>$z_{2,i}$</td>
<td>0.3322</td>
<td>0.5988</td>
<td>1.0000</td>
<td>1.6701</td>
<td>3.0099</td>
</tr>
<tr>
<td>$\pi$</td>
<td>0.0731</td>
<td>0.2422</td>
<td>0.3694</td>
<td>0.2422</td>
<td>0.0731</td>
</tr>
</tbody>
</table>

The calculation is based on Gauss-Hermite quadrature with 11 nodes. Then, the 4 nodes of each tail distribution are combined and adjusted to match the first 2 moments.

3.4 Government’s Policy Functions

We estimate the parameters of the Gouveia-Strauss type individual income tax function by OLS with the statutory marginal tax rates in 2009. One of the parameters, $\varphi_t$, is the limit of the marginal tax rate as taxable income goes to infinity. Thus, we set $\varphi_t$ 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 (equal weighted for taxable income between $0 and $500,000), separately for married households filing jointly and single households. Figure 2 shows the statutory marginal income tax rates and the estimated ones.

![Figure 2: The Marginal Income Tax Rate Schedule of Married and Single Households](image)

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 age...
cohorts when they reach age 62 in the U.S. system. For simplicity, we fix the growth-adjusted thresholds for all age cohorts and adjust the PIA of each age cohort later by using the long-term productivity growth rate and years from age 60. Thus, we simply use the thresholds for age 62 cohorts in 2009 after scale adjustment. The OASDI benefit adjustment factor, $\psi_t$, is 1.0 in the baseline economy. Recall that the AIME is calculated based on the highest 35 years of OASI taxable earnings in the U.S. system. However, the average historical earnings in our model is calculated based on the earnings in the whole working years. Monte Carlo simulation shows that the average earnings of the highest 35 years is about 12% higher than the simple average of 45 years. Thus, the AIME adjustment factor, $\vartheta_0$, is set at 1.12. To balance the OASI budget, we also set $TR_O = 0.3558$, which is 13.9% 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, $TR_O$, also consists of survivors benefits received by worker’s children and parents, which are not considered in the present paper.

### 3.5 Time Discount Factor and Other Policy Variables

In the baseline economy, the capital-output ratio, $K/Y$, is targeted to 2.7 by choosing the time discount factor, $\beta$, and the life cycle wealth-output ratio, $W_P/Y$, is 1.8 by assuming there is additional private wealth, $W_O$, determined by motives other than life cycle and precautionary saving motives against working ability shocks. Saving motives that could enhance private wealth accumulation but not considered in this paper are altruistic bequests, entrepreneurship, and precautionary motives against health and other expenditure shocks. Without introducing “other” wealth, the time discount factor that generates $K/Y = 2.7$ observed in the data will be significantly greater than one, which will generate a steeply increasing age-consumption profile and over-emphasize the importance of life cycle savings. Individual income tax revenue, $T_{I,t}$, is 10.7% of GDP and it is 4.0428 in the baseline economy. We assume $C_{G,t} = T_{I,t}$ and $TR_{LS,t} = W_{G,t} = 0$ so that the government budget is balanced. Federal individual income tax revenue is 6.4% as a percentage of GDP in 2009, but it was 8.4% in 2007 under the same marginal tax schedule (Congressional
Budget Office, 2010). Tax revenue is still overestimated in the model economy because we do not consider exemptions for children, child tax credits, and other tax saving measures such as 401(k) accounts and housing assets.

3.6 The Property of the Baseline Economy

In the present paper, we do not estimate model’s parameters with the data. However, we check if the baseline economy is acceptably consistent with the current U.S. economy. Table 3 shows the shares of annual OASI benefits by type of benefits: benefits received by workers themselves, wives and husbands, and widows and widowers. Since we do not have children in our model economy, we exclude benefits received by worker’s children, widow(er)ed parents of children, and worker’s parents from the calculation.

The first panel shows the shares calculated from the raw data in table 4.A5 in Social Security Administration (2010). The share of worker’s own benefits is stable around 74.0% until mid 1990s, then it increases gradually. It is on average 76.1% in 1999-2005 and rises to 78.9% in 2008. The shares of spousal benefits and survivors benefits received by widow(er)s are 4.5% and 16.6%, respectively, in 2008. The second panel of Table 3 shows the shares of OASI benefits with marital status adjustment. According to Table A1 of Families and Living Arrangements (U.S. Census Bureau, 2010), the shares of unmarried and divorced households among those aged 65 or older are increasing in recent years. We assume that 80% of divorced people get divorced within 10 years of their marriage thus not eligible for spousal and survivors benefits. Excluding these unmarried and part of divorced households, the share of worker’s own benefits is reduced to on average 73.5% in 1999-2005, and it is also reduced to 76.2% in 2008. The shares of spousal and survivors benefits increase to 5.9% and 20.6% on average in 1999-2005, and these are 5.1% and 18.7% in 2008.

The last panel of Table 3 shows the corresponding shares generated in the baseline economies: the main baseline economy and 3 alternative economies. In the main economy, the shares are 74.2%, 5.8%, and 20.1%. Although these shares do not reflect the recent increase in the share of workers own benefits and the decrease in the other benefits, these roughly match the shares of past
<table>
<thead>
<tr>
<th></th>
<th>Retired workers</th>
<th>Wives and husbands</th>
<th>Widows widowers</th>
<th>(1) Never married</th>
<th>(2) Divorced</th>
<th>(1)+0.8(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calculated from the Raw Data</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999-2005</td>
<td>76.1</td>
<td>5.4</td>
<td>18.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>78.0</td>
<td>4.8</td>
<td>17.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>78.9</td>
<td>4.5</td>
<td>16.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>78.2</td>
<td>4.6</td>
<td>16.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>With Marital Status Adjustment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999-2005</td>
<td>73.5</td>
<td>5.9</td>
<td>20.6</td>
<td>3.9</td>
<td>7.4</td>
<td>9.8</td>
</tr>
<tr>
<td>2006</td>
<td>75.4</td>
<td>5.3</td>
<td>19.3</td>
<td>3.6</td>
<td>8.7</td>
<td>10.6</td>
</tr>
<tr>
<td>2007</td>
<td>75.9</td>
<td>5.2</td>
<td>18.9</td>
<td>3.8</td>
<td>8.7</td>
<td>10.8</td>
</tr>
<tr>
<td>2008</td>
<td>75.9</td>
<td>5.1</td>
<td>18.7</td>
<td>4.1</td>
<td>9.1</td>
<td>11.4</td>
</tr>
<tr>
<td><strong>Calibrated Baseline Economies</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Run 1</td>
<td>74.2</td>
<td>5.8</td>
<td>20.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Run 2</td>
<td>72.9</td>
<td>6.8</td>
<td>20.3</td>
<td>$\gamma = 3.0, \rho = 0.95$, random match</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Run 3</td>
<td>73.1</td>
<td>6.7</td>
<td>20.2</td>
<td>$\gamma = 4.0, \rho = 0.97$, random</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Run 4</td>
<td>75.7</td>
<td>4.5</td>
<td>19.7</td>
<td>$\gamma = 4.0, \rho = 0.95$, assortative</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Author’s calculation from Table 4.A5 in Social Security Administration (2010) and Table A1 in U.S. Census Bureau (2010). Benefits received by children, widowed mothers and fathers, and parents are excluded. The shares of never married and divorced are those in age 65 or older people. For the marital status adjustment, we assume that 80% of divorced people get divorced within 10 years of their marriage thus not eligible for spousal and survivors benefits.

10 years after the marital status adjustment.

In the main baseline economy, women’s average market work hours is 86.5% of men’s average work hours, and women’s labor supply in efficiency units is 69.5% of men’s labor supply. Women’s average working hours is overestimated in our model economy. According to Table 5 of U.S. Bureau of Labor Statistics (2010), the average working hours of female workers is calculated as 36.3 per week in 2009, and it is 89.7% of that of 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 $89.7\% \times 83.8\% = 75.2\%$.

If we force female working hours in the model economy to that in the U.S. data, then, the
share of worker’s own benefits discussed above will not match the corresponding OASI statistics. This discrepancy is probably caused by the rule to calculate the average indexed monthly earnings (AIME) in the current OASI program. The AIME is calculated from the highest 35 years earnings. Thus, even if women are not in the labor market for 5 to 10 years for child care or other reasons, it is not likely that their AIME and primary insurance amounts (PIA) will be reduced significantly, although their labor participation rate and average working hours will be reduced by 10 to 20%. In the present paper, we focus on spousal and survivors benefits instead of the 35-year rule of AIME calculation, and we do not try to match the labor participation rate to the data.

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 gradually removes spousal and survivors benefits of OASI program cohort by cohort. 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 \( t \geq 1 \),

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

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 \( t \geq 1 \),

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

Finally, for households aged between 22 (i = 2) and 60 (i = 40), their OASI benefit function is assumed to be the weighted average of the above two functions, i.e., for \( 2 \leq i - (t - 1) \leq 40 \) and
\[ t \geq 1, \]
\[ tr^T_{SS,t}(i, b_1, b_2, m) = \frac{i - t}{40} tr^0_{SS,t}(i, b_1, b_2, m) + \left(1 - \frac{i - t}{40}\right) tr^1_{SS,t}(i, b_1, b_2, m). \]

**Government’s Financing Assumptions.** Any changes in the current Social Security system would change the government’s income and payroll tax revenue. When spousal and survivors benefits 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, we assume that the OASI budget is balanced in each period, the payroll tax rate, \( \bar{\tau}_{P,t} \), are fixed at the baseline level, and the benefits are changed proportionally in each period by the adjustment factor, \( \psi_t \), 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 individual income tax revenue. We assume that the rest of the government budget is also balanced in each period, and either government consumption, \( C_{G,t} \), lump-sum transfers, \( tr_{LS,t} \), or marginal income tax rates, parameter \( \varphi_t \), are 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.** We calculate the welfare gains or losses of age 21 \( (i = 1) \) households at the beginning of \( t = 1, \ldots, \infty \) 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,

$$\lambda_{1,t} = \left[ \left( \frac{E v(s_1, S_t; \Psi_t)}{E v(s_1, S_0; \Psi_0)} \right)^{\frac{1}{\alpha(1-\gamma)}} - 1 \right] \times 100.$$ 

Similarly, we calculate the average welfare changes of households of age $i$ at the time of policy change ($t = 1$) 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,

$$\lambda_{i,1} = \left[ \left( \frac{E v(s_i, S_1; \Psi_1)}{E v(s_i, S_0; \Psi_0)} \right)^{\frac{1}{\alpha(1-\gamma)}} - 1 \right] \times 100.$$ 

Note that $\lambda_{i,1}$ for $i = I, \ldots, 1$ shows the cohort-average welfare changes of all current households alive at the time of policy change, and $\lambda_{1,t}$ for $t = 2, \ldots, \infty$ 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 with the government budget balanced by (a) increasing government consumption, (b) introducing lump-sum transfers, and (c) decreasing marginal income tax rates.

Run 1 (a) assumed that the government increased its consumption to balance the budget. By removing spousal and survivors benefits, women’s market work hours would increase by 3.3% and labor supply in efficiency units would increase by 2.0% from the baseline economy. The increase in the latter is smaller because women with lower wages would be affected by the policy change more than those with higher wages. Men’s market work hours would increase only by 0.1%, and labor supply would not change. The ratio of women’s market work hours to men’s work hours would rise by 2.8 percentage points from 86.5% to 89.3%, and the ratio of women’s labor supply to men’s labor supply would rise by 1.5 percentage points from 69.5% to 71.0%.

Overall, total labor supply in efficiency units would increase by 0.8%, and capital stock (na-
Table 4: The Long-Run Effects of Removing Spousal and Survivors Benefits in the Main Baseline Economy (% changes from the baseline economy)

<table>
<thead>
<tr>
<th>Financing assumption</th>
<th>1 (a) Increasing government consumption</th>
<th>1 (b) Increasing lump-sum transfers</th>
<th>1 (c) Reducing income tax rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital stock (national wealth)</td>
<td>1.5</td>
<td>1.4</td>
<td>2.2</td>
</tr>
<tr>
<td>Labor supply</td>
<td>0.8</td>
<td>0.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Total output (GDP)</td>
<td>1.0</td>
<td>0.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Private consumption</td>
<td>0.7</td>
<td>0.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Market work hours: men</td>
<td>0.1</td>
<td>0.0</td>
<td>0.4</td>
</tr>
<tr>
<td>Market work hours: women</td>
<td>3.3</td>
<td>3.1</td>
<td>3.6</td>
</tr>
<tr>
<td>Labor supply (efficiency units): men</td>
<td>0.0</td>
<td>-0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Labor supply (efficiency units): women</td>
<td>2.0</td>
<td>1.9</td>
<td>2.3</td>
</tr>
<tr>
<td>Working hour ratio (women/men)*1</td>
<td>2.8</td>
<td>2.7</td>
<td>2.8</td>
</tr>
<tr>
<td>Labor income ratio (women/men)*1</td>
<td>1.5</td>
<td>1.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Interest rate</td>
<td>-1.2</td>
<td>-1.2</td>
<td>-1.8</td>
</tr>
<tr>
<td>Average wage rate</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Welfare of age 21 households</td>
<td>0.1</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Government consumption</td>
<td>1.6</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Lump-sum transfers*2</td>
<td>0.0</td>
<td>1.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Marginal Income tax rates</td>
<td>0.0</td>
<td>0.0</td>
<td>-2.3</td>
</tr>
<tr>
<td>OASI payroll tax revenue</td>
<td>1.0</td>
<td>0.8</td>
<td>1.3</td>
</tr>
<tr>
<td>OASI benefit adjustment</td>
<td>11.5</td>
<td>11.4</td>
<td>11.7</td>
</tr>
</tbody>
</table>

*1 Changes in percentage points. In the baseline economy, the working hour ratio is 86.5%, and the labor income ratio is 69.5%. *2 Change as a percentage of the baseline tax revenue.

Table 4 shows that capital stock (national wealth) and total output (GDP) would increase by 1.5% and 1.0%, respectively, by the policy change. The OASI payroll tax revenue would increase by 1.0%. The increase rate is slightly higher than that of total labor supply, which implies that the increase rate in labor supply is higher for those whose earnings are below the maximum taxable earnings. The OASI benefit adjustment factor would increase by 11.5%. The removal of spousal and survivors benefits would allow the government to increase PIA even if the payroll tax revenue is unchanged.

The government would be able to increase its consumption by 1.6% to keep its budget balanced.\footnote{The government consumption and individual income tax revenue are both 10.7% of GDP in the baseline economy.} Since part of the increased resource is consumed by the government, private consumption
would increase only by 0.7%. The interest rate would fall by 1.2% or 0.06 percentage points, and the average wage rate would rise 0.2%. The welfare change in the consumption equivalence measure is 0.1% under this financing assumption.

Run 1 (b) assumed that the government would distribute extra tax revenue to all households as lump-sum transfers to balance the budget. The main difference from Run 1 (a) is an income effect due to lump-sum transfers. Under this assumption, women’s market work hours would increase by 3.1% and labor supply would increase by 1.9%. The increase rates are both lower than those in Run 1 (a). Total labor supply, capital stock, and GDP would increase by 0.7%, 1.4%, and 0.9%, respectively. Individual tax revenue would increase by 1.3%, and this extra tax revenue is distributed as lump-sum transfers. Private consumption would increase by 0.8%, which is 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 improve by 0.4% in the consumption equivalence measure.

Run 1 (c) assumed 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 3.6%, and labor supply would increase by 2.3%. Total labor supply, capital stock, and GDP would increase by 1.1%, 2.2%, and 1.4%, respectively. Private consumption would also increase by 1.4%. 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 2.3% (for example, from 25% to 24.425%) to balance the budget. The interest rate would fall by 1.8%, and the wage rate would rise by 0.3%. The average welfare of age 21 households would increase by 0.4% in the long run.

This ratio would increase to 10.8% in the long run by the policy change.
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 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).

Men’s market work hours are mildly hump-shaped for workers younger than age 66. Women’s market work hours are also hump-shaped but have a tendency to decline after age 40. As the husband and wife get older, the wage disparity tends to increase. 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 full-time 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, since 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 reduced 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 widow(er)s switch benefits from worker’s own benefits to survivors benefits when their spouses die. After the policy change, as households get older, widow(er)ed people would increase but their OASI benefits would be lower because of the removal of survivors benefits.

\footnote{Olivetti (2006) shows that women’s working hours in 1990 are hump-shaped but peaked in the age group 35-44. In our model economy, women’s working hours are almost flat or slightly decreasing for ages between 20 and 40. This discrepancy is partially due to the lack of schooling (in early 20s) and home production for child care (in 20s and 30s) in the model economy.}
Figure 3: The Long-Run Effects of Removing Spousal and Survivors Benefits over the Life Cycle
Table 5: Long-run Changes in Hours of Market Work of Age 40 Households (changes as a percentage of full-time work hours 0.36)

<table>
<thead>
<tr>
<th></th>
<th>Husband</th>
<th>Wife</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$e^1_2$</td>
<td>$e^2_2$</td>
</tr>
<tr>
<td>1 (a)</td>
<td>0.30</td>
<td>0.25</td>
</tr>
<tr>
<td>Increasing</td>
<td>-0.94</td>
<td>-0.67</td>
</tr>
<tr>
<td>government consumption</td>
<td>-1.11</td>
<td>-1.25</td>
</tr>
<tr>
<td></td>
<td>0.64</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>1.59</td>
<td>1.32</td>
</tr>
<tr>
<td>1 (b)</td>
<td>-0.67</td>
<td>-0.06</td>
</tr>
<tr>
<td>Increasing</td>
<td>-1.19</td>
<td>-0.88</td>
</tr>
<tr>
<td>lump-sum transfers</td>
<td>-1.30</td>
<td>-1.42</td>
</tr>
<tr>
<td></td>
<td>0.51</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>1.50</td>
<td>1.23</td>
</tr>
<tr>
<td>1 (c)</td>
<td>-0.24</td>
<td>0.37</td>
</tr>
<tr>
<td>Reducing</td>
<td>-0.84</td>
<td>-0.52</td>
</tr>
<tr>
<td>income tax rates</td>
<td>-0.96</td>
<td>-1.08</td>
</tr>
<tr>
<td></td>
<td>0.87</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>1.87</td>
<td>1.61</td>
</tr>
</tbody>
</table>

* Rows, $e^1_1, \ldots, e^5_1$, are the husband’s wage rates at age 40 ($i = 20$) from the lowest to the highest, and columns, $e^1_2, \ldots, e^5_2$, are the corresponding wife’s wage rates.

Table 5 shows the long-run changes in market work hours of age 40 ($i = 20$) people from the baseline economy. Rows, $e^1_1, \ldots, e^5_1$, are the husband’s wage levels at age 40, and the columns, $e^1_2, \ldots, e^5_2$, are the wife’s wage levels. Since some people do not work at all in the market, we calculate the changes in market work hours as a percentage of assumed full-time work hours 0.36.

In all 3 financing assumptions, the husband’s market work hours would increase most when his market wage rate is the lowest, $e^1_1$, and his wife’s market wage rate is the second highest, $e^3_2$, or when his market wage rate is the second lowest, $e^3_1$, and his wife’s market wage rate is the highest, $e^5_2$. For households of these 2 states, the husband’s market wage rate is significantly lower than his wife’s wage rate, and the husband expects to receive spousal benefits on his wife’s PIA. Depending on the government financing assumption and the state, the working hours of age 40 men in these states would increase on average by 6.4-7.3% as a percentage of full-time work hours.
Similarly, the wife’s market work hours would increase most when the state of the household is either \((e^3_1, e^1_2)\), \((e^4_1, e^2_2)\), \((e^5_1, e^2_2)\), or \((e^5_1, e^3_2)\), that is, the wife’s market wage is significantly lower relative to her husband’s. However, when wife’s wage rate is the lowest, \(e^1_2\), and her husband’s wage rate is high enough, \(e^4_1\) or \(e^5_1\), the increase rate of wife’s working hours would be much lower due to the income effect of her husband’s earnings.

### 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 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 working hours would jump up by 1.3-1.5\% in the first year of the policy change, then these would increase gradually to the long-run steady-state levels, which are 3.7-4.6\% 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 working hours would increase by 0.4-0.6\% in the first year, then these would also increase gradually to the long-run levels. Total labor supply in efficiency units would also increase by 0.4-0.6\% in the first year. The initial increase in capital stock would be much smaller, and it would be below the baseline level for the first 19 years if lump-sum transfers were introduced to balance the budget. 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 increase in private consumption would be smallest when government consumption was increased to balance the budget.

Age 21 households at the time of 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 removed completely from the economy. The OASI benefit adjustment factor, which compensates the removal of spousal and survivors benefits to balance the OASI budget, would increase gradually for the first 80 years. This adjustment factor would also increase because of the higher payroll tax
Figure 4: The Transition Effects of Removing Spousal and Survivors Benefits
revenue due to higher market labor activity.

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, and those shown right of the vertical line are future households.

The current elderly households aged 61 \((i = 41)\) or older would be better off by the policy change, because their OASI benefit function is unaffected by the policy change but their OASI benefits would increase because of the balanced-budget condition of the OASI program. The longer they are alive, the more gains they would get. The spousal and survivors benefits of current households aged 22 \((i = 2)\) and 60 \((i = 40)\) are partially removed, depending on their age. 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 35 or younger at the time of policy change would be on average worse off. However, when the additional tax revenue were distributed to households by either lump-sum transfers or marginal income tax rate cuts, all of the age cohorts would be on average better off. 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. Table 6 shows the welfare gains and losses of age 21 households in year one and in the long run by their initial wage levels.

Rows, \(e_{11}, \ldots, e_{51}\), are the husband’s wage levels at age 21 \((i = 1)\), and the columns, \(e_{21}, \ldots, e_{52}\), 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 the highest, \(e_{51}\), and the wife’s wage rate is the lowest, \(e_{21}\). The current age 21 households of this wage combination would be worse off by 1.92% if the policy change was financed by lump-sum transfers and by 1.83% if it was financed alternatively by the marginal tax rate cuts. Under these financing assumptions, age 21 households on the diagonal and in the upper triangle, \((e_{11}, e_{k2})\) for \(j \leq k\), tend to be better off, those in the lower triangle, \((e_{11}, e_{2k})\) for \(j > k\), tend to be worse off. However, if
Table 6: Welfare Changes of Age 21 Households in the Economy with Random Matching

<table>
<thead>
<tr>
<th></th>
<th>At the policy change ($t = 1$)</th>
<th>In the final steady state ($t = \infty$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$e_1^1$ $e_2^1$ $e_3^1$ $e_4^1$ $e_5^1$</td>
<td>$e_1^2$ $e_2^2$ $e_3^2$ $e_4^2$ $e_5^2$</td>
</tr>
<tr>
<td>1 (a) Increasing</td>
<td>-0.28 -0.14 -0.09 -0.20 -0.41</td>
<td>0.10 0.25 0.30 0.18 -0.11</td>
</tr>
<tr>
<td>government</td>
<td>-0.56 -0.28 -0.08 -0.04 -0.14</td>
<td>-0.18 0.10 0.30 0.33 0.17</td>
</tr>
<tr>
<td>consumption</td>
<td>-1.08 -0.64 -0.25 0.00 0.08</td>
<td>-0.71 -0.27 0.12 0.36 0.39</td>
</tr>
<tr>
<td></td>
<td>-1.76 -1.20 -0.63 -0.17 0.14</td>
<td>-1.42 -0.85 -0.29 0.17 0.42</td>
</tr>
<tr>
<td></td>
<td>-2.34 -1.78 -1.11 -0.47 0.03</td>
<td>-2.10 -1.53 -0.84 -0.22 0.25</td>
</tr>
<tr>
<td>1 (b) Increasing</td>
<td>0.40 0.46 0.45 0.29 0.03</td>
<td>1.73 1.54 1.35 1.05 0.61</td>
</tr>
<tr>
<td>lump-sum</td>
<td>0.03 0.26 0.41 0.42 0.27</td>
<td>1.09 1.19 1.23 1.13 0.85</td>
</tr>
<tr>
<td>transfers</td>
<td>-0.55 -0.15 0.20 0.42 0.47</td>
<td>0.31 0.65 0.94 1.08 1.02</td>
</tr>
<tr>
<td></td>
<td>-1.29 -0.75 -0.21 0.22 0.49</td>
<td>-0.60 -0.08 0.42 0.81 0.99</td>
</tr>
<tr>
<td></td>
<td>-1.92 -1.39 -0.73 -0.12 0.35</td>
<td>-1.44 -0.90 -0.25 0.33 0.74</td>
</tr>
<tr>
<td>1 (c) Reducing</td>
<td>-0.08 0.11 0.22 0.19 0.06</td>
<td>0.65 0.87 1.02 1.03 0.91</td>
</tr>
<tr>
<td>income</td>
<td>-0.31 0.01 0.27 0.38 0.36</td>
<td>0.45 0.80 1.10 1.25 1.25</td>
</tr>
<tr>
<td>tax rates</td>
<td>-0.76 -0.28 0.16 0.46 0.62</td>
<td>0.03 0.54 1.02 1.37 1.55</td>
</tr>
<tr>
<td></td>
<td>-1.36 -0.76 -0.15 0.36 0.73</td>
<td>-0.54 0.09 0.74 1.30 1.70</td>
</tr>
<tr>
<td></td>
<td>-1.83 -1.26 -0.55 0.13 0.69</td>
<td>-1.01 -0.40 0.36 1.09 1.70</td>
</tr>
</tbody>
</table>

* The equivalence variation measure in consumption, %. Rows, $e_1^1, \ldots, e_5^1$, are the husband’s wage rates at age 21 ($i = 1$) from the lowest to the highest, and columns, $e_2^2, \ldots, e_5^2$, are the corresponding wife’s wage rates.

The husband’s wage is very low, $e_1^1$, and the wife’s wage is significantly high, $e_5^2$, the household’s welfare gain by the policy change would be smaller.

### 4.4 Individual Contributions of Spousal and Survivors Benefits

In this section, we analyze the long-run effects of spousal benefits and survivors benefits separately and show the relative importance of these 2 benefits. In Table 3, the share of spousal benefits (benefits received by wives and husbands) is 5.8%, and the share of survivors benefits (benefits received by widows and widowers) is 20.1% in our baseline economy. Are the policy effects of these two benefits roughly proportional to these shares? Table 7 shows the results.

The second panel of Table 7 shows the effects of removing spousal benefits only. Women’s market work hours would increase by 1.7-2.0%. The increase rates are about 54% 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, labor supply in efficiency units would increase by 0.4-0.6%, 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 gains of age 21 households are also small. These households would be better off only by 0.0-0.1%.

The third panel of the same table shows the effect of removing survivors benefits only. Women’s market work hours would increase by 2.8-3.5%. Surprisingly, more than 90% of the increase in female working hours is explained by removing survivors benefits. We also see that the effect of removing these 2 types of benefits are not additively separable. Men’s market work hours would increase by 0.1-0.6%. In total, labor supply would increase by 0.8-1.3%, capital stock

<table>
<thead>
<tr>
<th>Financing assumption</th>
<th>(a) Increasing government consumption</th>
<th>(b) Increasing lump-sum transfers</th>
<th>(c) Reducing income tax rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total output (GDP)</td>
<td>1.0</td>
<td>0.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Labor supply (efficiency units)</td>
<td>0.8</td>
<td>0.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Market work hours: men</td>
<td>0.1</td>
<td>0.0</td>
<td>0.4</td>
</tr>
<tr>
<td>Market work hours: women</td>
<td>3.3</td>
<td>3.1</td>
<td>3.6</td>
</tr>
<tr>
<td>Welfare of age 21 households</td>
<td>0.1</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

1A. Removing spousal benefits only

| Total output (GDP)                    | 0.4                                   | 0.3                               | 0.6                          |
| Labor supply (efficiency units)       | 0.5                                   | 0.4                               | 0.6                          |
| Market work hours: men                | 0.3                                   | 0.2                               | 0.4                          |
| Market work hours: women              | 1.8                                   | 1.7                               | 2.0                          |
| Welfare of age 21 households          | 0.0                                   | 0.1                               | 0.1                          |

1B. Removing survivors benefits only

| Total output (GDP)                    | 1.2                                   | 1.0                               | 1.7                          |
| Labor supply (efficiency units)       | 1.0                                   | 0.8                               | 1.3                          |
| Market work hours: men                | 0.3                                   | 0.1                               | 0.6                          |
| Market work hours: women              | 3.1                                   | 2.8                               | 3.5                          |
| Welfare of age 21 households          | 0.0                                   | 0.4                               | 0.5                          |
would increase by 1.5-2.5%, and total output would increase by 1.0-1.7. The increase rates of these macroeconomic variables are all higher than those when removing both benefits. The age 21 households would be better off by 0.0-0.5%.

In the presence of survivors benefits, removing spousal benefits would increase labor supply in efficiency units by 0.4-0.6% (Run 1A). However, in the absence of survivors benefits, removing spousal benefits would decrease labor supply by 0.1-0.2% (Runs 1B and 1), although total working hours would still increase.

5 Policy Reform in the Alternative Baseline Economies

In this section, we show the effects of removing spousal and survivors benefits in 3 alternative baseline economies: the economy with lower relative risk aversion (Run 2), the economy with higher persistence in wage shocks (Run 3), and the economy with married couples with assortative matching (Run 4). Table 8 shows the results of the same policy experiments in these 3 alternative economies as well as in the main baseline economy.

Our utility function is additively separable between husband and wife as well as across time. Thus, when we reduce the coefficient of relative risk aversion, $\gamma$, from 4.0 to 3.0, it will also change the intra-temporal (intra-household) elasticity substitution of husband’s working hours for wife’s working hours. The elasticity of substitution is increased to $\frac{1-\alpha}{\alpha} \frac{1}{(1-\alpha)(1-\gamma)-1} = 0.78$ from 0.61. The second panel of the table shows the results. With the higher intra-household elasticity, women’s working hours would increase by 3.9-4.4% from the new baseline economy. The increase rates are 0.8 percentage points higher than those in our main policy experiments. The increase rates in GDP would be slightly higher in this economy, and the welfare changes in age 21 households would also be higher when the marginal income tax rates are reduced after the policy change.

How about the effect of removing spousal and survivors benefits in the economy with higher wage persistence? If the transitory wage shocks are more persistent, households can predict their future wage rates and OASI primary insurance amounts more accurately. Thus, the labor supply
Table 8: The Long-Run Effects of Removing Spousal and Survivors Benefits in Alternative Economies (% changes from the baseline economy)

<table>
<thead>
<tr>
<th>Financing assumption</th>
<th>(a) Increasing government consumption</th>
<th>(b) Increasing lump-sum transfers</th>
<th>(c) Reducing income tax rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Main baseline economy (γ = 4.0, ρ = 0.95, random matching)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total output (GDP)</td>
<td>1.0</td>
<td>0.9</td>
<td>1.4</td>
</tr>
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<td>Labor supply (efficiency units)</td>
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</tr>
<tr>
<td>Welfare of age 21 households</td>
<td>0.1</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

| 2. Lower risk aversion (γ = 3.0, ρ = 0.95, random matching) |                                       |                                 |                             |
| Total output (GDP)              | 1.1                                   | 0.9                              | 1.5                         |
| Labor supply (efficiency units) | 0.9                                   | 0.8                              | 1.2                         |
| Market work hours: men          | 0.1                                   | -0.1                             | 0.3                         |
| Market work hours: women        | 4.1                                   | 3.9                              | 4.4                         |
| Welfare of age 21 households    | 0.1                                   | 0.4                              | 0.5                         |

| 3. Higher wage persistence (γ = 4.0, ρ = 0.97, random matching) |                                       |                                 |                             |
| Total output (GDP)              | 1.2                                   | 1.0                              | 1.6                         |
| Labor supply (efficiency units) | 1.0                                   | 0.8                              | 1.3                         |
| Market work hours: men          | 0.4                                   | 0.2                              | 0.7                         |
| Market work hours: women        | 3.8                                   | 3.6                              | 4.2                         |
| Welfare of age 21 households    | 0.1                                   | 0.5                              | 0.5                         |

| 4. Higher wage correlation (γ = 4.0, ρ = 0.95, assortative matching) |                                       |                                 |                             |
| Total output (GDP)              | 0.8                                   | 0.7                              | 1.1                         |
| Labor supply (efficiency units) | 0.6                                   | 0.5                              | 0.8                         |
| Market work hours: men          | -0.1                                  | -0.3                             | 0.0                         |
| Market work hours: women        | 2.8                                   | 2.6                              | 3.0                         |
| Welfare of age 21 households    | 0.1                                   | 0.4                              | 0.3                         |

The reaction of households to the policy change will be larger compared to the main policy experiment. The third panel shows the results. In the economy with more persistent wage shocks, women’s market work hours would increase by 3.6-4.2% from the new baseline economy. The increase rates in working hours are 0.5-0.6 percentage points higher than those in the main baseline economy. Total output would increase by 1.0-1.6%. The increase rates are 0.1-0.2 percentage points higher, and the change is larger compared to Run 2 even though women’s labor supply response is smaller.
The welfare effects are also slightly larger compared to those in the main baseline economy.

The last panel of Table 8 shows the effects of removing spousal and survivors benefits from the economy with assortative matching. We made the following assumption: At age 21, the husband’s market wage rate and the wife’s wage rate are assumed to be perfectly correlated, i.e., the combination of initial wage rates is \((e_{11}^1, e_{12}^1), (e_{21}^2, e_{22}^2), \ldots, (e_{51}^5, e_{52}^5)\). However, for simplicity, we also assume the same Markov transition probability, corresponding to \(\rho = 0.95\), as before. Thus, the wage correlation is assumed to decrease as a married couple get older. Under this assumption, the husband’s market wage rate and the wife’s wage rate will be relatively close and fewer couples will expect to receive spousal and survivors benefits. By the removal of these benefits, women’s market work hours would increase only by 2.6-3.0% from the new baseline economy. The increase rates are 0.5-0.6 percentage points lower than those in the main baseline economy. Total output would increase by 0.7-1.1%. The welfare effects of the policy change in this baseline economy are slightly smaller compared to the main baseline economy.

Overall, the effects of the policy change on female labor supply would depend on the values of some parameters. 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

To make the model and the decision making of married couples as simple as possible, we assumed a unitary utility model in the present paper. 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, we assumed no possibilities of divorce in the model economy. Although the risk of separation would probably affect the labor supply and saving decisions due to precautionary motives, keeping the historical earnings of history of ex spouses would make the general equilibrium model computationally intractable. In the future, however, we will try to relax these assumptions by introducing imperfect altruism and the strategic interactions between a husband and a wife and by possibly
introducing marriage and divorce decisions.

Through the policy experiments, we have shown to what extent the removal of spousal and survivors benefits from the OASI program would likely increase the labor supply of married couples and also on average improve the well-being of the households, although the policy change would not be strictly Pareto improving. The model can also provide some predictions how much female labor supply would increase as the wage difference between male and female workers will be narrowed in the near future. Also, an extended version of the model will help designing the optimal benefit schedule of the Social Security OASI program. [TO BE COMPLETED.]

A Computational Algorithm

We solve the household’s optimization problem recursively from age \( i = I \) to age \( i = 1 \) by discretizing the asset space, \( A = [0, a_{\text{max}}] \), into 21 nodes, \( \hat{A} = \{a^1, a^2, \ldots, a^{21}\} \), the average historical earning space, \( B = [0, b_{\text{max}}] \), into 12 nodes each, \( \hat{B} = \{b^1, b^2, \ldots, b^{12}\} \), and the working ability space, \( E = [0, e_{\text{max}}] \), into 5 nodes for a husband and a wife of each age, \( \hat{E}_1, i = \{e^1_{1,i}, e^2_{1,i}, \ldots, e^5_{1,i}\} \) and \( \hat{E}_2, i = \{e^1_{2,i}, e^2_{2,i}, \ldots, e^5_{2,i}\} \).

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

\[
\Omega_t = \{r_s, w_s, C_{G,s}, tr_{LS,s}, \varphi_s, \tau_{P,s}, \psi_s, W_{G,s}\}_{s=t}^{\infty}
\]

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

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

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

taking \( \Omega_t \) as given. For the numerical methods to solve a Kuhn-Tucker condition for household’s optimal decision, see Judd (1998) and Miranda and Fackler (2002). For 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 \( v(s; \Omega_{t+1})\big|_{i=I+1} = 0 \). The household’s problem at age \( i \) in period \( t \) is modified to

\[
v(s; \Omega_t) = \max_{c,l_1,l_2} \left\{ u(c, l_1, l_2; m) + \beta \phi_{m,i} E \left[ \left. v(s'; \Omega_{t+1}) \right| s \right] \right\}
\]

subject to the constraints for the decision variables,

- \( 0 < c \leq c_{\text{max}}, \quad l_1 = 1 - h_1, \quad l_2 = 1 - h_2, \)
- \( 0 < l_1 \leq 1 \) if \( m \neq 2, \quad l_1 = 1 \) if \( m = 2, \)
- \( 0 < l_2 \leq 1 \) if \( m \neq 1, \quad l_2 = 1 \) if \( m = 1, \)

and the law of motion of the state variables,

\[
s' = (i + 1, a', b_1', b_2', e_1', e_2', m'),
\]

\[
c_{\text{max}} = (1 + r_t)a + w_t e_1 h_1 + w_t e_2 h_2 - \tau_{I,t}(r_t a + w_t e_1 h_1 + w_t e_2 h_2; m)
\]

\[
- \tau_{P,t}(w_t e_1 h_1, w_t e_2 h_2) + tr_{SS,t}(i, b_1, b_2, m) + (1 + 1_{\{m=0\}}) tr_{LS,t},
\]

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\[
a' = \frac{1}{(1 + \mu)\phi_{m,i}} [c_{\text{max}} - c],
\]

\[
b_j' = 1_{\{i < I_R\}} \frac{1}{i} [(i - 1)b_j + \min(\partial_0 w_t e_j h_j, \vartheta_{\text{max}})] + 1_{\{i \geq I_R\}} b_j \quad \text{for } j = 1, 2.
\]

Let the objective function be

\[
f(c, l_1, l_2; s, \Omega_t) = u(c, l_1, l_2; m) + \tilde{\beta} \phi_{m,i} E \left[ v(s'; \Omega_{t+1}) \mid s \right].
\]

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

(15) \quad f_c(c, l_1, l_2; s, \Omega_t) = u_c(c, l_1, l_2; m) - \frac{\tilde{\beta}}{1 + \mu} E \left[ v_a(s'; \Omega_{t+1}) \mid s \right] = 0,

(16) \quad f_{l_1}(c, l_1, l_2; s, \Omega_t) = u_{l_1}(c, l_1, l_2; m)
\quad - w_t e_1 \left[ 1 - \tau'_{l,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_c(c, l_1, l_2; m)
\quad - 1_{\{i < I_R, w_t e_1 < \vartheta_{\text{max}}\}} \frac{\partial_0 w_t e_1}{i} \tilde{\beta} \phi_{m,i} E \left[ v_b(s'; \Omega_{t+1}) \mid s \right] = 0,

(17) \quad f_{l_2}(c, l_1, l_2; s, \Omega_t) = u_{l_2}(c, l_1, l_2; m)
\quad - w_t e_2 \left[ 1 - \tau'_{l,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_c(c, l_1, l_2; m)
\quad - 1_{\{i < I_R, w_t e_2 < \vartheta_{\text{max}}\}} \frac{\partial_0 w_t e_2}{i} \tilde{\beta} \phi_{m,i} E \left[ v_b(s'; \Omega_{t+1}) \mid s \right] = 0,

where \(\tau'_{l,t}(r_t a + w_t e_1 h_1 + w_t e_2 h_2; m)\) 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 (15) is the Euler equation, and equations (16) and (17) 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,

\[
f_c(c, l_1, l_2; s, \Omega_t) = 0 \quad \text{if} \quad 0 < c < c_{\text{max}}, \quad > 0 \quad \text{if} \quad c = c_{\text{max}},
\]

\[
f_{l_1}(c, l_1, l_2; s, \Omega_t) = 0 \quad \text{if} \quad 0 < l_1 < 1, \quad > 0 \quad \text{if} \quad l_1 = 1,
\]
\[ f_{l_2}(c, l_1, l_2; s, \Omega_t) = 0 \text{ if } 0 < l_2 < 1, \quad > 0 \text{ if } l_2 = 1, \]

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

\[
(18) \quad \min \left\{ \max \left[ \begin{pmatrix} f_c(c, l_1, l_2; s, \Omega_t) \\ f_{l_1}(c, l_1, l_2; s, \Omega_t) \\ f_{l_2}(c, l_1, l_2; s, \Omega_t) \end{pmatrix}, \begin{pmatrix} \epsilon - c \\ \epsilon - l_1 \\ \epsilon - l_2 \end{pmatrix} \right], \begin{pmatrix} c_{\text{max}} - c \\ 1 - l_1 \\ 1 - l_2 \end{pmatrix} \right\} = 0,
\]

where \( \epsilon \) 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 (18) for \( c(s; \Omega_t) \), \( l_1(s; \Omega_t) \), and \( l_2(s; \Omega_t) \) by using a Newton-type nonlinear equation solver, NEQNLF, in the Fortran IMSL library.

Once we obtain the optimal decision, we next calculate the value of the household with state \( s \) in period \( t \) as

\[
(19) \quad v(s; \Omega_t) = u(c(s; \Omega_t), l_1(s; \Omega_t), l_2(s; \Omega_t); m) + \tilde{\beta}_m E \left[ v(s'; \Omega_{t+1}) \mid s \right],
\]

and the corresponding marginal values as

\[
(20) \quad v_a(s; \Omega_t) = \left[ 1 + r_t \left( 1 - r_{I,t}(r_t a + w_t e_1 h_1(s; \Omega_t) + w_t e_2 h_2(s; \Omega_t)); m \right) \right] \\
\times u_c(c(s; \Omega_t), l_1(s; \Omega_t), l_2(s; \Omega_t); m),
\]

\[
(21) \quad v_{b_1}(s; \Omega_t) = tr_{SS,b_1,(i,b_1,b_2,m)} u_c(c(s; \Omega_t), l_1(s; \Omega_t), l_2(s; \Omega_t); m) \\
+ \left( 1_{i < I_R} \frac{i - 1}{i} + 1_{i \geq I_R} \right) \tilde{\beta}_m E \left[ v_{b_1}(s'; \Omega_{t+1}) \mid s \right],
\]

\[
(22) \quad v_{b_2}(s; \Omega_t) = tr_{SS,b_2,(i,b_1,b_2,m)} u_c(c(s; \Omega_t), l_1(s; \Omega_t), l_2(s; \Omega_t); m)
\]
\[
+ \left( 1_{\{i < i_R\}} \frac{i - 1}{i} + 1_{\{i \geq i_R\}} \right) \tilde{\beta}_m \phi_{s', \Omega} E \left[ \nu_m(s'; \Omega_{t+1}) | s \right],
\]

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

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

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

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

\[
\psi_b(i, j) = 1_{\{i \geq i_R\}} (1 + \mu)^{40-i} \left\{ 1_{\{b_j < \varphi_1\}} 0.90 + 1_{\{\varphi_1 \leq b_j < \varphi_2\}} 0.32 + 1_{\{\varphi_2 \leq b_j\}} 0.15 \right\}
\]

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

\[
tr^1_{SS,b_1,t}(i, b_1, b_2, m) = \psi_t \psi_b(i, b_1) \quad \text{if } m = 0 \text{ or } 1, \quad = 0 \quad \text{if } m = 2,
\]

\[
tr^1_{SS,b_2,t}(i, b_1, b_2, m) = \psi_t \psi_b(i, b_2) \quad \text{if } m = 0 \text{ or } 2, \quad = 0 \quad \text{if } m = 1.
\]

References


