Achieving Actuarial Balance in Social Security: Measuring the Welfare Effects on Individuals

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Aging population affects the individual decision as follows:

- With lower mortality rates and higher life expectancy, individual households would save more by working longer for their retirement. [direct effect]
- With fewer children, households would likely consume less for dependent children. [not considered]
- Possible changes in factor prices and government policies would affect the households’ current and future decisions further. [G.E. effects]
Effects of Aging Population on the Overall Economy

Aging population affects the overall economy as follows:

- With the lower (higher) share of working-age (elderly) population, the labor supply per capita and GDP per capita would decrease.
- The government tax revenue per capita would likely decrease, and its transfer spending would increase.
- To finance the budgetary cost of aging, the government would have to raise taxes and/or cut spending.
- These fiscal policy changes would affect the overall economy further. [G.E. effects]
Main Questions of This Paper

This paper addresses the following questions:

▶ How would the U.S. aging population affect the individual behavior and the overall economy?
▶ How large would the cost of the aging population in the Social Security pension (OASI) program be?
▶ How should (could) the government close the fiscal gap generated by the aging population?
▶ How would different policy changes to close the fiscal gap affect the overall economy and the welfare of households?
The Approach of This Paper

This paper quantitatively analyzes the effect of the U.S. aging population in a heterogeneous-agent OLG economy in the following way:

▶ Incorporating SSA’s population projection to a G.E. OLG model with idiosyncratic wage shocks.

▶ Constructing the aging baseline (calibrated to 2015 U.S. economy) as an equilibrium transition path over 1975–2200.

▶ Solving the model for 2016–2200 with alternative reform plans to close the fiscal gap in the Social Security pension (OASI) program.
Recent Related Literature

On the U.S. aging population
- Bewley-type heterogeneous-agent OLG economy
  Kitao (RED2014), Nishiyama (JEDC2015)
- Representative-agent OLG economy
  Kotlikoff, Smetters & Walliser (JME2007) and many others

On the Japanese aging population
- Bewley-type heterogeneous-agent OLG economy
  Yamada (JEDC2012), Kitao (JEDC2015)
- Representative-agent OLG economy
  Braun & Joines (JEDC2015), İmrohoroğlu, Kitao & Yamada (IER2016), etc.
The Model Economy

The economy consists of

- a large number of heterogeneous & OLG households,
- a perfectly-competitive representative firm with CRS production technology,
- a government with a commitment technology.

A model period is a year. In a stationary equilibrium, the economy grows with

- the labor-augmenting productivity growth rate, $\mu$, of 1.5%,
- the long-run population growth rate, $\nu$, which is about 0.31%.
Heterogeneous Households

Households are heterogeneous with respect to

- ages, \( i = 21, \ldots, I \),
- beginning-of-period wealth, \( a \),
- average historical earnings, \( b \),
- working ability, \( e \).

In each period \( t \), the households each receive idiosyncratic working ability shocks, \( e \), and choose

- consumption, \( c \),
- working hours, \( h \),
- wealth at the beginning of the next period, \( a' \),

to maximize their (remaining) lifetime utility.
Individual & Aggregate States

The individual state of the heterogeneous households is

\[ s = (i, a, b, e). \]

The aggregate state vector of the economy in period \( t \) is

\[ S_t = (x_t(s), w_{G,t}, W_{S,t}), \]

which consists of

- the joint distribution function of households, \( x_t(s) \),
- the government’s net worth per capita, \( w_{G,t} \),
- the Social Security (OASI) trust funds, \( W_{S,t} \).
The Government Policy Schedule

The government policy schedule as of period $t$ is

$$\psi_t = \left\{ c_{G,s}, tr_{LS,s}, \tau_{I,s}(\cdot), \tau_{P,s}(\cdot), tr_{SS,s}(\cdot), \tau_{C,s}, w_{G,s+1}, W_{S,s+1} \right\}_{s=t}^{\infty},$$

which includes

- the government’s consumption per capita, $c_{G,t}$,
- lump-sum transfers per capita, $tr_{LS,t}$,
- progressive income tax function, $\tau_{I,t}(\cdot)$,
- Social Security payroll tax function, $\tau_{P,t}(\cdot)$,
- Social Security benefit function, $tr_{SS,t}(\cdot)$,
- flat consumption tax rate, $\tau_{C,t}$.
The Population Projection

The population projection as of period $t$ is,

$$\Phi_t = \left\{ (p_{i,s})_{i=0}^l, (\phi_{i,s})_{i=0}^l \right\}_{s=t}^\infty,$$

which consists of

- the population, $p_{i,s}$, of age $i$ households in year $s$,
  - changes in $p_{i,s}$ includes changes in net immigrants,
- the survival rate, $\phi_{i,s}$, at the end of age $i$ in year $s$,

for $i = 0, \ldots, l$ and $s = t, \ldots, \infty$, each of which satisfies

$$p_{i,s} = \int_{A \times B \times E} x_s(i, a, b, e) da db de = \int_{A \times B \times E} dX_s(s).$$
The Household’s Optimization Problem

The optimization problem is

$$v(s, S_t; \psi_t, \Phi_t) = \max_{c, h, a'} \left\{ u(c, h) + \beta \phi_{i,t} E \left[ v(s', S_{t+1}; \psi_{t+1}, \Phi_{t+1}) \mid s \right] \right\}$$

subject to the constraints of the decision variables,

$$c > 0, \quad 0 \leq h < h_{\text{max}}, \quad a' \geq 0,$$

and the law of motion of the individual state,

$$s' = (i + 1, a', b', e').$$
The Laws of Motion of the State

The laws of motion of the individual state are

- the intertemporal budget constraint,

\[
a' = \frac{1}{1 + \mu} \left[ (1 + r_t)a + w_t eh + tr_{SS,t}(i, b) + tr_{LS,t} + q_t \right. \\
- \left. \tau_{l,t}(w_t eh, r_t a, tr_{SS,t}(i, b)) - \tau_{P,t}(w_t eh) - (1 + \tau_{C,t})c \right],
\]

- the average historical earnings,

\[
b' = 1_{\{i < l_R\}} \frac{1}{i - 20} \left[ (i - 21) b \frac{w_t}{w_{t-1}} + \min(w_t eh, \vartheta_{max}) \right] \\
+ 1_{\{i \geq l_R\}} b.
\]
The Decision Rules of the Households

Solving the above problem for $c$, $h$, and $a'$, we obtain the household’s decision rules as

$$c(s, S_t; \psi_t, \phi_t), \quad h(s, S_t; \psi_t, \phi_t), \quad a'(s, S_t; \psi_t, \phi_t),$$

and

$$b'(s, S_t; \psi_t, \phi_t) = 1_{\{i < I_R\}} \frac{1}{i - 20} \left[ (i - 21) b \frac{w_t}{w_{t-1}} + \min(w_t e h(s, S_t; \psi_t, \phi_t), \vartheta_{max}) \right] + 1_{\{i \geq I_R\}} b.$$
Solving the Household Problem (1)

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,

$$\Omega_t = \{ r_s, w_s, c_{G,s}, tr_{LS,s}, \tau_{I,s}(\cdot), \tau_{P,s}(\cdot), tr_{SS,s}(\cdot), \tau_{C,s},$$

$$w_{G,s+1}, W_{S,s+1} \}_{s=t}^{\infty}.$$  

Since the dimension of the aggregate state vectors in $\nu(s, S_t; \psi_t, \Phi_t)$ is infinite, it is almost impossible to solve the above problem—“the curse of dimensionality”.

In the absence of aggregate productivity or policy shocks, however, we can avoid this by replacing $(S_t, \psi_t, \Phi_t)$ with $\Omega_t$. 
Solving the Household Problem (2)

Let \( l \) be leisure, \( l = h_{\text{max}} - h \), and let the objective function be

\[
f(c, l; s, \Omega_t) = u(c, l) + \beta \phi_{i,t} E[ v(s'; \Omega_{t+1}) \mid s ].
\]

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

\[
f_c(c, l; s, \Omega_t) = u_c(c, l) - \frac{\beta \phi_{i,t} (1 + \tau_{C,t})}{1 + \mu} E[ v_a(s'; \Omega_{t+1}) \mid s ] = 0,
\]

\[
f_l(c, l; s, \Omega_t) = u_l(c, l) - w_t e \left[ 1 - \tau_{l,1,t} (w_t e(h_{\text{max}} - l), r_t a) - \tau'_{P,t} (w_t e(h_{\text{max}} - l)) \right] \frac{u_c(c, l)}{1 + \tau_{C,t}}
\]

\[
- \mathbb{1}_{\{i < r_R, w_t e(h_{\text{max}} - l) < \vartheta_{\text{max}}\}} \frac{w_t e}{i} \beta \phi_{i,t} E[ v_b(s'; \Omega_{t+1}) \mid s ] = 0,
\]

where \( \tau_{l,1,t} ( ) \) and \( \tau'_{P,t} ( ) \) are the marginal labor income and payroll tax rates, respectively.
Solving the Household Problem (3)

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,

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

\[ f_l(c, l; s, \Omega_t) = 0 \quad \text{if} \quad 0 < l < h_{\text{max}}, \quad > 0 \quad \text{if} \quad l = h_{\text{max}}, \]

where \( c_{\text{max}} = c + a' \) and \( a' \geq 0 \).

This complementarity problem is expressed more compactly as the nonlinear system of equations,

\[
CP(c, l) = \min \left\{ \max \left[ \begin{pmatrix} f_c(c, l; s, \Omega_t) \\ f_l(c, l; s, \Omega_t) \end{pmatrix}, \begin{pmatrix} \varepsilon - c \\ \varepsilon - l \end{pmatrix}, \begin{pmatrix} c_{\text{max}} - c \\ h_{\text{max}} - l \end{pmatrix} \right] \right\} = 0,
\]

where \( \varepsilon \) is a small positive number.
The Distribution of the Households (1)

The households of age 21 enter the economy with no assets and working histories, i.e.,

$$\int_{A\times B\times E} dX_t(21, a, b, e) = \int_{E} dX_t(21, 0, 0, e) = p_{21,t},$$

where $p_{21,t}$ is normalized to unity in 2015. The population distribution of the age 21 households is exogenous,

$$x_t(21, 0, 0, e) = \pi_{21}(e) \times p_{21,t},$$

where $\pi_{21}(e)$ is the unconditional probability density function of working ability at age 21.
The Distribution of the Households (2)

For $i = 21, \ldots, l$, the growth-adjusted population distribution of households is obtained recursively by

$$x_{t+1}(s') = x_{t+1}(i + 1, a', b', e')$$

$$= \frac{\phi_{i,t}}{1 + \nu} \int_{A \times B \times E} 1\{a' = a'(s, S_t; \psi_t, \Phi_t), b' = b'(s, S_t; \psi_t, \Phi_t)\} \times \pi_i(e' \mid e) dX_t(s),$$

where $\pi_i(e' \mid e)$ is the conditional probability density function of working ability $e'$ at age $i + 1$ given $e$ at age $i$. 
The Supply of Capital and Labor

Private wealth, government wealth, domestic wealth (capital stock), and labor supply are calculated as

\[ W_{P,t} = \sum_{i=21}^{I} \int_{A \times B \times E} a \, dX_t(s), \]

\[ W_{G,t} = w_{G,t} \sum_{i=21}^{I} p_{i,t}, \]

\[ K_t = W_{P,t} + W_{G,t}, \]

\[ L_t = \sum_{i=21}^{I} \int_{A \times B \times E} eh(s, S_t; \psi_t, \phi_t) \, dX_t(s). \]
Production Factor Prices

From the representative firm’s profit-maximizing condition and the market-clearing condition, the rate of return to capital, \( r_t \), and the average wage rate, \( w_t \), are obtained as

\[
\begin{align*}
  r_t &= F_K(K_t, L_t) - \delta, \\
  w_t &= F_L(K_t, L_t),
\end{align*}
\]

where \( F(K_t, L_t) \) is a Cobb-Douglas production function,

\[
F(K_t, L_t) = A K_t^\theta L_t^{1-\theta}.
\]
The Government Revenue and Expenditure

- The government’s income tax revenue, $T_{l,t}$, payroll tax revenue, $T_{P,t}$, and consumption tax revenue, $T_{C,t}$, are obtained by using the distribution of households, $x_t(s)$.

- The government purchases, $C_{G,t}$, non-S.S. (lump-sum) transfer spending, $TR_{LS,t}$, and S.S. transfer spending, $TR_{SS,t}$, are also obtained by using $x_t(s)$.

- The government collects wealth left by deceased households as accidental bequests, and it redistributes the revenue uniformly, $q_t$, to all households.
The Government’s Tax Revenue

The government’s income tax revenue, $T_{I,t}$, payroll tax revenue, $T_{P,t}$, and consumption tax revenue, $T_{C,t}$, are obtained as

$$
T_{I,t} = \sum_{i=21}^{l} \int_{A \times B \times E} \tau_{I,t}(w_{t} eh(s, S_{t}; \psi_{t}, \phi_{t}), r_{t} a, tr_{SS,t}(i, b); \varphi_{t}) \, dX_{t}(s),
$$

$$
T_{P,t} = \sum_{i=21}^{l} \int_{A \times B \times E} \tau_{P,t}(w_{t} eh(s, S_{t}; \psi_{t}, \phi_{t}); \tau_{P,t}) \, dX_{t}(s),
$$

$$
T_{C,t} = \sum_{i=21}^{l} \int_{A \times B \times E} \tau_{C,t} c(s, S_{t}; \psi_{t}, \phi_{t}) \, dX_{t}(s),
$$

where $\varphi_{t}$ is a parameter of the income tax function, and $\tau_{P,t}$ is the OASI payroll tax rate on earnings below the max taxable earnings.
The Government’s Expenditure

The government’s purchases, $C_{G,t}$, non-S.S. (lump-sum) transfer spending, $TR_{LS,t}$, and S.S. transfer spending, $TR_{SS,t}$, are obtained as

$$C_{G,t} = c_{G,t} \sum_{i=21}^{l} p_{i,t}, \quad TR_{LS,t} = tr_{LS,t} \sum_{i=21}^{l} p_{i,t},$$

$$TR_{SS,t} = \sum_{i=21}^{l} \int_{A \times B \times E} tr_{SS,t}(i, b; \psi_{SS,t}) dX_t(s),$$

where $\psi_{SS,t}$ is the OASI benefit adjustment factor.
The Government’s Intertemporal Budget Constraint

The government budget is assumed to be unified, and it satisfies the following constraint,

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

The OASI trust funds, \( W_{S,t} \), are the accounting tool to check the sustainability of the program,

\[ W_{S,t+1} = \frac{1}{(1 + \mu)(1 + \nu)} \max \left[ 0, (1 + r_t)W_{S,t} + T_{P,t}(\tau_{P,t}) ight. \\
- TR_{SS,t}(\psi_{SS,t}) \left. \right] . \]
Recursive Competitive Equilibrium

A time series of factor prices, the gov’t policy variables, the value functions, the decision rules, and the distribution of households are in a recursive competitive equilibrium if, for all \( s = t, \ldots, \infty, \)

- the households each solve their utility maximization problem, taking the current state of the economy, the gov’t policy schedule, and the population projection as given;
- the firm solves its profit maximization problem, taking factor prices as given;
- the government follows its policy schedule; and
- the goods and factor markets clear.
Population Projection

This paper uses SSA’s intermediate population projection (1941–2100) provided for the 2014 trustees report.

This paper extrapolates SSA’s projection through 2200 by using

- the projected mortality rates in 2099,
- the age-specific fertility rates in 2100 (estimated from the 2006 fertility rates).

Under these assumptions, the population distribution in 2200 is almost stationary, but the distribution in 2015 is non-stationary.
Population Distribution by Age in Selected Years (1)

Growth-adjusted by the long-run growth rate \( \nu \) (\( \rho_{21,2015} = 1.0 \))

<table>
<thead>
<tr>
<th>Year</th>
<th>Working-Age Pop. (21-64) / Elderly Pop. (65+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>Working-Age Pop. / Elderly Pop. = 5.10</td>
</tr>
<tr>
<td>1995</td>
<td>Working-Age Pop. / Elderly Pop. = 4.56</td>
</tr>
<tr>
<td>2015</td>
<td>Working-Age Pop. / Elderly Pop. = 4.00</td>
</tr>
<tr>
<td>2035</td>
<td>Working-Age Pop. / Elderly Pop. = 2.55</td>
</tr>
<tr>
<td>2055</td>
<td>Working-Age Pop. / Elderly Pop. = 2.51</td>
</tr>
<tr>
<td>2075</td>
<td>Working-Age Pop. / Elderly Pop. = 2.32</td>
</tr>
<tr>
<td>2095</td>
<td>Working-Age Pop. / Elderly Pop. = 2.15</td>
</tr>
<tr>
<td>2100</td>
<td>Working-Age Pop. / Elderly Pop. = 2.09</td>
</tr>
</tbody>
</table>
Growth-adjusted by the long-run growth rate $\nu$ ($\rho_{21,2015} = 1.0$)

- **2055**: Working-Age Pop. / Elderly Pop. = 2.51
- **2075**: Working-Age Pop. / Elderly Pop. = 2.32
- **2100**: Working-Age Pop. / Elderly Pop. = 2.15
- **2200**: Working-Age Pop. / Elderly Pop. = 2.09
The Calibration Procedure (1)

This paper constructs the aging-population baseline as follows:

1. the paper first solves the model for a 1975 stationary equilibrium by using the historical population distribution in 1975, assuming the households falsely believe that the population distribution is time-invariant;

2. the paper next solves the model for a 2200 stationary equilibrium and an equilibrium transition path in 1975–2200 by using the projected population distribution, assuming the households suddenly realize that the population distribution is aging in 1975.
The Calibration Procedure (2)

To finance the budgetary cost of the aging population, the aging-population baseline economy assumes that the gov’t decreases its consumption spending so that the wealth (debt) per capita stays at the 2015 level after growth adjustment.

This policy change will not affect the households’ decision, because the government’s consumption is not in the households’ utility function or the budget constraint.

Repeating the above steps 1 and 2, the parameters of the model are chosen so that the model economy in 2015 over the transition path is consistent with the 2015 U.S. economy.
### Main Parameter Values in the Aging Baseline

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum age</td>
<td>$I$</td>
<td>100</td>
</tr>
<tr>
<td>Maximum age households can work</td>
<td></td>
<td>80</td>
</tr>
<tr>
<td>Minimum age of elderly households</td>
<td>$I_R$</td>
<td>66</td>
</tr>
<tr>
<td>Productivity growth rate</td>
<td>$\mu$</td>
<td>0.0150</td>
</tr>
<tr>
<td>Long-run population growth rate</td>
<td>$\nu$</td>
<td>0.0032</td>
</tr>
<tr>
<td>Total population (ages 21–100) in 2015</td>
<td></td>
<td>52.470</td>
</tr>
<tr>
<td>Working-age population (ages 21–65) in 2015</td>
<td></td>
<td>42.725</td>
</tr>
<tr>
<td><strong>Preferences</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discount factor</td>
<td>$\beta$</td>
<td>1.0012</td>
</tr>
<tr>
<td>Growth-adjusted discount factor</td>
<td>$\tilde{\beta}$</td>
<td>0.9816</td>
</tr>
<tr>
<td>Coefficient of relative risk aversion</td>
<td>$\gamma$</td>
<td>3.0000</td>
</tr>
<tr>
<td>Share parameter of consumption</td>
<td>$\alpha$</td>
<td>0.6613</td>
</tr>
<tr>
<td><strong>Production technology and wage process</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share parameter of capital stock</td>
<td>$\theta$</td>
<td>0.3700</td>
</tr>
<tr>
<td>Depreciation rate of capital stock</td>
<td>$\delta$</td>
<td>0.0733</td>
</tr>
<tr>
<td>Total factor productivity</td>
<td>$A$</td>
<td>0.8910</td>
</tr>
<tr>
<td>Auto correlation parameter of log wage</td>
<td>$\rho$</td>
<td>0.9500</td>
</tr>
<tr>
<td>Standard deviation of log wage shocks</td>
<td>$\sigma$</td>
<td>0.2800</td>
</tr>
<tr>
<td>Average hourly wage by age</td>
<td>$\bar{e}_i$</td>
<td></td>
</tr>
</tbody>
</table>
### Policy Parameter Values in the Aging Baseline

#### Table 2: Fiscal Policy Parameter Values of the Aging-Population Baseline Economy under Alternative 2

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model units</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxable labor income ratio <strong>η</strong></td>
<td>0.6810</td>
<td>SS covered earnings / NIPA labor income in 2013</td>
</tr>
<tr>
<td>Scale adjustment <strong>a</strong></td>
<td>96.596</td>
<td>Average earnings $71,475 in 2015</td>
</tr>
<tr>
<td><strong>Progressive income tax</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income tax: tax rate limit <strong>φ_t</strong></td>
<td>0.3960</td>
<td>Target: ( T_{I,t}/Y_t = 0.106 ) in 2015</td>
</tr>
<tr>
<td>: curvature <strong>φ_1</strong></td>
<td>0.7653</td>
<td>( { ) Estimated by OLS</td>
</tr>
<tr>
<td>: scale <strong>φ_2</strong></td>
<td>0.5412</td>
<td></td>
</tr>
<tr>
<td>: deduction/exemptions <strong>b</strong> <strong>d</strong></td>
<td>0.1706</td>
<td>( 0.6 \times 20,600 + 0.4 \times 10,300 ) in 2015</td>
</tr>
<tr>
<td><strong>Social Security system</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.S. payroll tax rate: OASI <strong>τ_P,t</strong></td>
<td>0.1060</td>
<td>Statutory rate in 2015</td>
</tr>
<tr>
<td>Maximum taxable earnings <strong>c</strong></td>
<td>1.5334</td>
<td>1.25 × $118,500 in 2015</td>
</tr>
<tr>
<td>Repl. rate threshold: 0.90 &amp; 0.32 <strong>c</strong></td>
<td>0.1280</td>
<td>1.25 × $824 × 12 in 2015</td>
</tr>
<tr>
<td>: 0.32 &amp; 0.15 <strong>c</strong></td>
<td>0.6451</td>
<td>1.25 × $4,154 × 12 in 2015</td>
</tr>
<tr>
<td>Benefit adjustment factor: OASI <strong>ψ_t</strong></td>
<td>1.6753</td>
<td>Target: benefits 4.1% of GDP in 2015</td>
</tr>
<tr>
<td><strong>Other policy variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government’s consumption per capita <strong>c_G,t</strong></td>
<td>0.1518</td>
<td>Calculated as a residual</td>
</tr>
<tr>
<td>Consumption tax rate <strong>τ_C,t</strong></td>
<td>0.0286</td>
<td>Target: ( T_{C,t}/Y_t = 0.017 ) in 2015</td>
</tr>
<tr>
<td>Government’s net worth per capita <strong>w_G,t</strong></td>
<td>-1.0183</td>
<td>Target: ( W_{G,t}/Y_t = -0.70 ) in 2015</td>
</tr>
<tr>
<td>Social Security (OASI) trust fund <strong>W_S,t</strong></td>
<td>11.6024</td>
<td>Target: ( W_{S,t}/Y_t = 0.152 ) in 2015</td>
</tr>
</tbody>
</table>

\( \text{Note: This baseline calibration uses the population projection Alternative 2 (intermediate scenario) for Social Security Administration (2014).} \)

\( \text{a A unit in the model economy corresponds to $96,596 in 2015 growth-adjusted dollars.} \)

\( \text{b 60\% of all households are assumed to be married, and the other 40\% of households are single.} \)

\( \text{c Each married household is assumed to have 1.25 full-time equivalent workers.} \)

\( \text{3.7 The Social Security System} \)

The Social Security OASDHI payroll tax function is

\[
\tau_{P,t}(w_t) = (\tau_{O,t} + \tau_{D,t}) \min(\eta \cdot w_t, \vartheta_{\text{max}}) + \tau_{H,t} \eta \cdot w_t + \tau_{HS,t} \max(\eta \cdot w_t - \vartheta_3, 0),
\]

where \( \tau_{O,t} \) is the flat Old-Age and Survivors Insurance (OASI) tax rate, \( \tau_{D,t} \) is the flat Disability Insurance (DI) tax rate, \( \tau_{H,t} \) is a flat Hospital Insurance (HI, Medicare Part A) tax rate, and \( \tau_{HS,t} \) is a flat HI surtax rate. These payroll tax rates include the portion of taxes paid by employers. The payroll tax revenues for the OASI, DI, and HI programs are 3.70%, 0.63%, and 1.32%, respectively, as a share of GDP in 2013, according to Tables 4.A1, 4.A2, and 8.A1 in Social Security Administration (2014). This paper sets \( \tau_{HS,t} \) at 0.009, which is the statutory HI surtax rate. Then, this paper sets \( \tau_{O,t}, \tau_{D,t}, \) and \( \tau_{H,t} \) at 0.1007, 0.0172, and 0.0305, respectively, so that the payroll tax revenues for the OASI, DI, and HI programs as a share of GDP in 2013 is 18%. 
This paper uses the SSA’s population projection over 1941-2100 and extrapolates it through 2200.
Demographics in the Aging-Population Economy (2)

The old age dependency ratio indicates how the aging population will affect the Social Security budget in the future.

Old Age Dependency Ratio
(Ages 65-120 to 21-64)
Demographics in the Aging-Population Economy (3)

The decreasing share of working-age population partially explains how labor supply per capita will change in the future.

The Proportion of Working-Age Population
(Ages 21-64 to 21-120)

Year
1980 2000 2020 2040 2060 2080 2100 2120
Ratio
0.65
0.70
0.75
0.80
0.85

Stationary Population
Aging Population
The Aging-Population Baseline Economy (1)

% changes from the 2015 growth-adjusted economy

- Capital Stock Per Capita
- Labor Supply Per Capita
- Gross Domestic Product Per Capita
- Private Consumption Per Capita

---

Cutting Government Consumption
The Aging-Population Baseline Economies (2)

% changes from the 2015 growth-adjusted economy

- Rate of Return to Capital
- Average Wage Rate
- SS (OASI) Benefits Per Capita
- Tax Revenue Per Capita

— Cutting Government Consumption
The Aging-Population Baseline Economies (3)

% changes from the 2015 growth-adjusted economy

--- Cutting Government Consumption

![Graph showing Gov't Consumption Per Capita and Income, Payroll, and Cons. Tax Rates](image)
Fiscal Gap of the OASI Program

The government is assumed to keep its consumption in 2016–2200 at the 2015 level instead of cutting it to finance the budgetary cost of aging population.
Increasing Payroll Tax vs Cutting Benefits (1)

According to the 2016 Social Security Trustees Report, the OASI program would be sustainable for the next 75 years if the government introduced either one of the following policy changes:

▶ increasing the OASI payroll tax immediately by 2.25 pp;
▶ cutting the OASI benefits immediately & proportionally by 15.8%.

In each of these policy experiments, in addition, the government adjusts the consumption tax rate so that the wealth (debt) per capita stays at the 2015 level after growth adjustment.
Increasing Payroll Tax vs Cutting Benefits (2)

% changes from the 2015 growth-adjusted economy

- **Capital Stock Per Capita**
  - Aging Baseline Economy
  - Decreasing OASI Benefits by 15.8%

- **Labor Supply Per Capita**
  - Increasing OASI Tax Rate by 2.25pp

- **Gross Domestic Product Per Capita**

- **Private Consumption Per Capita**
Increasing Payroll Tax vs Cutting Benefits (3)

% changes from the 2015 growth-adjusted economy

**Rate of Return to Capital**

**Average Wage Rate**

**SS (OASI) Benefits Per Capita**

**Payroll Tax Revenue Per Capita**

---

- **Aging Baseline Economy**
- **Increasing OASI Tax Rate by 2.25pp**
- **Decreasing OASI Benefits by 15.8%**
Increasing Payroll Tax vs Cutting Benefits (4)

% changes from the 2015 growth-adjusted economy

- **Consumption Tax Rate**
  - Aging Baseline Economy
  - Decreasing OASI Benefits by 15.8%

- **SS (OASI) Trust Fund / GDP**
  - Increasing OASI Tax Rate by 2.25pp
Increasing Payroll Tax vs Cutting Benefits (5)

% changes from the aging baseline economy

Consumption Equivalence

Compensating Variations ×(-1)

-140 -120 -100 -80 -60 -40 -20 0 20 40 60 80 100
% Ch in Consumption Equivalence

-100 -80 -60 -40 -20 0 20
Wealth Transf. as % of GDP Per Capita

Age in 2016

-12.0 -10.0 -8.0 -6.0 -4.0 -2.0 0.0 2.0
Increasing OASI Tax Rate by 2.25pp

Decreasing OASI Benefits by 15.8%
The annual maximum taxable earnings in 2015 and 2016 are both $118,500. All (covered) earnings are taxable for Medicare (HI) but only those below $118,500 are taxable for OASDI.

The share of taxable earnings has decreased from 90.0% in 1982-83 to 82.5% in 2015.
Removing Max Taxable Earnings (1)

To improve the actuarial balance of the OASI program, the government is assumed to remove the maximum taxable earnings together with either one of the following changes:

- removing the maximum of annual earnings for the calculation of AIME as well.
  - The benefits of high-earnings workers will increase in the future.

- keeping the maximum of annual earnings for the calculation of AIME at the current level.

In each of these policy experiments, in addition, the government adjusts the consumption tax rate.
Removing Max Taxable Earnings (2)

% changes from the 2015 growth-adjusted economy

- Capital Stock Per Capita
- Labor Supply Per Capita
- Gross Domestic Product Per Capita
- Private Consumption Per Capita

---
- Cutting Government Consumption
- Removing Max Taxable Earnings 1
- Removing Max Taxable Earnings 2
Removing Max Taxable Earnings (3)

% changes from the 2015 growth-adjusted economy
Removing Max Taxable Earnings (4)

% changes from the 2015 growth-adjusted economy

Consumption Tax Rate

SS (OASI) Trust Fund / GDP

Cutting Government Consumption

Removing Max Taxable Earnings 1

Removing Max Taxable Earnings 2
Removing Max Taxable Earnings (5)

% changes from the aging baseline economy

![Graphs showing consumption equivalence and wealth transfer as a percentage of GDP per capita](image)

- Raising Max Taxable Earnings 1
- Raising Max Taxable Earnings 2
Taxing All Benefits vs Raising FRA (1)

The OASI benefits are partially income-taxable if the sum of the other income and 50% of benefits is larger than $25,000 for a single household and $32,000 for a married household.

To close the fiscal gap, the government is assumed to introduce one of the following policy changes:

- making all OASI benefits taxable and move the increase in income tax revenue into the OASI budget;
- raising the full retirement age of the program gradually from age 67 to age 70.

In each of these policy experiments, in addition, the government adjusts the consumption tax rate.
Taxing All Benefits vs Raising FRA (2)

% changes from the 2015 growth-adjusted economy

- Capital Stock Per Capita
- Labor Supply Per Capita
- Gross Domestic Product Per Capita
- Private Consumption Per Capita

Cutting Government Consumption
Raising Full Retirement Age to 69

Making All OASI Benefits Taxable
Taxing All Benefits vs Raising FRA (3)

% changes from the 2015 growth-adjusted economy

- Rate of Return to Capital
- Average Wage Rate
- SS (OASI) Benefits Per Capita
- Payroll Tax Revenue Per Capita

- Cutting Government Consumption
- Raising Full Retirement Age to 69
- Making All OASI Benefits Taxable
Taxing All Benefits vs Raising FRA (4)

% changes from the 2015 growth-adjusted economy

- Cutting Government Consumption
- Raising Full Retirement Age to 69
- Making All OASI Benefits Taxable
Taxing All Benefits vs Raising FRA (5)

% changes from the aging baseline economy

% Ch in Consumption Equivalence

% Ch in Consumption Equivalence

Wealth Transf. as % of GDP Per Capita

Compensating Variations ×(-1)

Age in 2016

Age in 2016

Making All OASI Benefits Taxable

Raising Full Retirement Age to 70
Concluding Remarks

The years of OASI Trust Funds depletion and long-run changes in the GDP per capita (%) and the consumption tax rate (p.p.) are as follows:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Trustees Rep. 2016</th>
<th>OLG model economy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>year</td>
<td>GDP</td>
</tr>
<tr>
<td>Do nothing (baseline)</td>
<td>2035</td>
<td>-6.9%</td>
</tr>
<tr>
<td>Incr. payroll tax by 2.25pp</td>
<td>2090</td>
<td>-7.5%</td>
</tr>
<tr>
<td>Decr. benefits by 15.8%</td>
<td>2090</td>
<td>-4.7%</td>
</tr>
<tr>
<td>Rem. max taxable earn. 1</td>
<td>-</td>
<td>-9.2%</td>
</tr>
<tr>
<td>Rem. max taxable earn. 2</td>
<td>-</td>
<td>-8.5%</td>
</tr>
<tr>
<td>Make all benefits taxable</td>
<td>-</td>
<td>-5.3%</td>
</tr>
<tr>
<td>Raise FRA from 67 to 70</td>
<td>-</td>
<td>-5.5%</td>
</tr>
</tbody>
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