The impact of introducing a pension sustainability factor on inequality and growth

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Motivation

• **Facts:**
  Rapid increase in life expectancy and healthy years → Ageing process

• Research interest:
  What is the impact of modifying the pension system on income distribution and growth when individuals are heterogeneous?
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  - **Individual ageing** (great heterogeneity):
    education, income → retirement, savings

  - **Population ageing:**
    Structural change in the age distribution of the population → labor and capital
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  What is the impact of modifying the pension system on income distribution and growth when individuals are heterogeneous?
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- **Literature:**
  - Correlation between education, health, labor market, and length of life:
    Chakraborty (2004), Chakraborty and Das (2005)
  - Pension system without cohort heterogeneity:
    Keuschnigg and Keuschnigg (2004), Fisher and Keuschnigg (2010), Jaag et al. (2010), Fehr et al. (2013), etc...
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- **Model:** Large scale computable general equilibrium model with two productive sectors (health and final good) and a social security system calibrated to the Austrian economy

- **Heterogeneity:**
  - Exogenous: Ability, health, and effort of attending school (parental background)
  - Endogenous: Educational attainment and life expectancy
Model: Parametric components of past and present Austrian pension systems

- **Contribution period**
  - Benefits are calculated according to an ordered vector of the highest past labor incomes
    
    \[ p \in \mathbb{R}^{py}, \text{ where } p_1 > p_2 > p_3 > \cdots > p_{py} \]

  - Pensionable income years (py)
  - Accrual rate \( \phi^P(z) \)
  - Pension base Increment (PBI): \( \max \{ y_{lt}, p_{py} \} \rightarrow \) Pension base (PB)
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- **Benefit period**
  - Early retirement \( (R_e) \), normal retirement \( (R_n) \), and late retirement \( (R_l) \)
  - Years contributed vs. Targeted years worked
  - Penalties and rewards for early and late retirement
  - Pension replacement rate
Model: Household Problem

Given a random set of endowments \( \xi = (\theta_H, D_0, \phi_E) \in \Xi \), an educational level \( E \in \mathbf{E} \), and the set of state variables \( \mathbf{X}_t^a = \{A_t^a, H_t^a, D_t^a, P_t^a\} \), our individual chooses consumption, labor, and health spending that maximize the following Bellman equation:

\[
J_t^a(\mathbf{X}_t^a; E, \xi) = \max_{C_t^a, L_t^a, M_t^a} \left\{ F(D_t^a)U(C_t^a, L_t^a; E, \xi) + \beta \eta_{t+1}(E)J_{t+1}^{a+1}(\mathbf{X}_{t+1}^{a+1}; E, \xi) \right\}
\]
Model: Household Problem

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\]

subject to

\[
A_{t+1}^a = R_t^a(E, \tau_t^R)A_t^a + (1 - \tau_t^L)[(1 - \tau_t^S)w_t \epsilon_t^a(E)H_t^aL_t^a + b_t^a \alpha_R(L_t^a)]
\]
\[
- (1 + \tau_t^C)C_t^a - (1 + \tau_t^M)p_t^M M_t^a,
\]
Given a random set of endowments $\xi = (\theta_H, D_0, \phi_E) \in \Xi$, an educational level $E \in E$, and the set of state variables $X_t^a = \{A_t^a, H_t^a, D_t^a, P_t^a\}$, our individual chooses consumption, labor, and health spending that maximize the following Bellman equation:

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subject to

$$A_{t+1}^a = R_t^a(E, \tau_t^R) A_t^a + (1 - \tau_t^L) \left[ (1 - \tau_t^S) w_t \epsilon_t^a(E) H_t^a L_t^a + b_t^a \alpha_R(L_t^a) \right] - (1 + \tau_t^C) C_t^a - (1 + \tau_t^M) p_t^M M_t^a,$$

$$H_{t+1}^a = (1 - \delta(D_t^a)) H_t^a, + 1\{a < E\} \theta_H(H_t^a) \gamma^H$$
Model: Household Problem

Given a random set of endowments \( \xi = (\theta_H, D_0, \phi_E) \in \Xi \), an educational level \( E \in E \), and the set of state variables \( X^a_t = \{ A^a_t, H^a_t, D^a_t, P^a_t \} \), our individual chooses consumption, labor, and health spending that maximize the following Bellman equation:

\[
J^a_t(X^a_t; E, \xi) = \max_{C^a_t, L^a_t, M^a_t} \left\{ F(D^a_t)U(C^a_t, L^a_t; E, \xi) + \beta \gamma^a_{t+1}(E) J^a_{t+1}(X^a_{t+1}; E, \xi) \right\}
\]

subject to

\[
A^{a+1}_{t+1} = R^a_t(E, \tau^R_t)A^a_t + (1 - \tau^L_t) \left[ (1 - \tau^S_t)w_t \epsilon^a(E)H^a_tL^a_t + b^a_t \alpha_R(L^a_t) \right] \\
- (1 + \tau^C_t)C^a_t - (1 + \tau^M_t)p^M_t M^a_t,
\]

\[
H^{a+1}_{t+1} = (1 - \delta(D^a_t))H^a_t + 1\{a < E\} \theta_H(H^a_t)^{\gamma_H}
\]

\[
D^{a+1}_{t+1} = (1 + \beta_D)D^a_t - \beta_D(\theta_D(M^a_t)^{\gamma_D} + \gamma_D),
\]
Given a random set of endowments $\xi = (\theta_H, D_0, \phi_E) \in \Xi$, an educational level $E \in \mathbf{E}$, and the set of state variables $X_t^a = \{ A_t^a, H_t^a, D_t^a, P_t^a \}$, our individual chooses consumption, labor, and health spending that maximize the following Bellman equation:

$$J_t^a(X_t^a; E, \xi) = \max_{C_t^a, L_t^a, M_t^a} \left\{ F(D_t^a) U(C_t^a, L_t^a; E, \xi) + \beta \gamma_{t+1}^a(E) J_{t+1}^a(X_{t+1}^a; E, \xi) \right\}$$

subject to

$$A_{t+1}^a = R_t^a(E, \tau_t^R) A_t^a + (1 - \tau_t^L) \left[ (1 - \tau_t^S) w_t \epsilon^a(E) H_t^a L_t^a + b_t \alpha_R(L_t^a) \right]$$

$$- (1 + \tau_t^C) C_t^a - (1 + \tau_t^M) p_t^M M_t^a,$$

$$H_{t+1}^a = (1 - \delta(D_t^a)) H_t^a + 1_{\{a < E\}} \theta_H(H_t^a)^{\gamma_H},$$

$$D_{t+1}^a = (1 + \beta_D) D_t^a - \beta_D (\theta_D(M_t^a)^{\gamma_D} + \gamma_D),$$

$$P_{t+1}^a = \hat{R}_t^a(L_t^a) P_t^a + \phi^P(t - a) \max \{ w_t \epsilon^a(E) H_t^a L_t^a - p_{py}, 0 \},$$
Model: Household Problem

Given a random set of endowments $\xi = (\theta_H, D_0, \phi_E) \in \Xi$, an educational level $E \in E$, and the set of state variables $X_t^a = \{A_t^a, H_t^a, D_t^a, P_t^a\}$, our individual chooses consumption, labor, and health spending that maximize the following Bellman equation:

$$J_t^a(X_t^a; E, \xi) = \max_{C_t^a, L_t^a, M_t^a} \left\{ F(D_t^a) U(C_t^a, L_t^a; E, \xi) + \beta \gamma_{t+1}^a(E) J_{t+1}^a(X_{t+1}^a; E, \xi) \right\}$$

subject to

$$A_{t+1}^a = R_t^a(E, \tau_t^R) A_t^a + (1 - \tau_t^L) [(1 - \tau_t^S) w_t e^a(E) H_t^a L_t^a + b_t^a \alpha_R(L_t^a)] - (1 + \tau_t^C) C_t^a - (1 + \tau_t^M) p_t^M M_t^a,$$

$$H_{t+1}^a = (1 - \delta(D_t^a)) H_t^a, + 1_{\{a < E\}} \theta_H(H_t^a)^{\gamma_H}$$

$$D_{t+1}^a = (1 + \beta_D) D_t^a - \beta_D(\theta_D(M_t^a)^{\gamma_D} + \gamma_D),$$

$$P_{t+1}^a = \hat{R}_t^a(L_t^a) P_t^a + \phi^P(t - a) \max \{w_t e^a(E) H_t^a L_t^a - p_{py}, 0\},$$

boundary conds $A_0^{t-a} = A_{t-a+T}^T = 0$, $H_0^{t-a} = H_0$, $D_0^{t-a} = D_0$, $P_0^{t-a} = 0$
Solution: State variables

- **Value of a unit of human capital** \( (\varphi_H = \lambda_H / \lambda_A) \)

\[
\varphi_H^a_t = \frac{R\varphi_H^a_t}{R_t^a(E, \tau_t^R)} \varphi_H^{a+1} + \frac{(1 - \tau H^a_t)w_t \epsilon^a_t(E)L_t}{R_t^a(E, \tau_t^R)}
\]
Solution: State variables

- **Value of a unit of human capital** ($\varphi_H = \lambda_H / \lambda_A$)

  $$\varphi_{Ht}^a = \frac{Rh_t^a}{R_t^a(E, \tau_t^R)} \varphi_{Ht+1}^{a+1} + \frac{(1 - \tau H_t^a)w_t^a E_t(L_t)w_t^a}{R_t^a(E, \tau_t^R)}$$

- **Value of reducing health deficits** ($\varphi_D = -\lambda_D / \lambda_A$)

  $$\varphi_{Dt}^a = \frac{1 + \beta_D}{R_t^a(E, \tau_t^R)} \varphi_{Dt+1}^{a+1} - \frac{F'(D_t^a) U(\cdot)}{F(D_t^a)} \frac{U_C(\cdot)}{U_C(\cdot)} \frac{R_t^a(E, \tau_t^R)}{R_t^a(E, \tau_t^R)} + \frac{\delta'(D_t^a) \varphi_{Ht+1}^{a+1} H_t^a}{R_t^a(E, \tau_t^R)},$$
Solution: State variables

• Value of a unit of human capital \( (\varphi_H = \lambda_H/\lambda_A) \)

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\varphi_{Ht}^a = \frac{R_{ht}^a}{R_t^a(E, \tau_t^R)} \varphi_{Ht+1}^{a+1} + \frac{(1 - \tau H_t^a)w_t \epsilon_t^a(E)L_t^a}{R_t^a(E, \tau_t^R)}
\]

• Value of reducing health deficits \( (\varphi_D = -\lambda_D/\lambda_A) \)

\[
\varphi_{Dt}^a = \frac{1 + \beta_D}{R_t^a(E, \tau_t^R)} \varphi_{Dt+1}^{a+1} - \frac{F'(D_t^a)}{F(D_t^a)} \frac{U(\cdot)}{U_C(\cdot)} \frac{(1 + \tau_t^C)}{R_t^a(E, \tau_t^R)} + \frac{\delta'(D_t^a) \varphi_{Ht+1}^{a+1} H_t^a}{R_t^a(E, \tau_t^R)},
\]

• Value of pension points \( (\varphi_P = \lambda_P/\lambda_A) \)

\[
\varphi_{Pt}^a = \frac{\hat{R}_t^a(L_t^a)}{R_t^a(E, \tau_t^R)} \varphi_{Pt+1}^{a+1} + \frac{(1 - \tau_t^L)}{R_t^a(E, \tau_t^R)} \frac{\partial b_t^a \alpha_R(L_t^a)}{\partial P_t^a}
\]
Solution: Control variables

- **First-order conditions**

\[
F(D^a_t) U_C(\cdot; E) = \beta \gamma^a_t(E) \lambda_{A_{t+1}}^a(1 + \tau^C_t)
\]

\[
\frac{U_L(\cdot; E)}{U_C(\cdot; E)} = (1 - \tau E^a_t) w_t \epsilon^a(E) H^a_t + \frac{1 - \tau^L_t}{1 + \tau^C_t} \frac{\partial b^a_t \alpha_R(L^a_t)}{\partial L^a_t} + \frac{\varphi_{P^a_{t+1}}}{1 + \tau^C_t} \frac{\partial \hat{R}^a_t(L^a_t)}{\partial L^a_t}
\]

\[
M^a_t = \left( \beta_D \theta_D \gamma_D \frac{-\varphi_{D^a_{t+1}}}{(1 + \tau^M_t) p^M_t} \right)^{\frac{1}{1 - \gamma_D}}
\]
Solution: Control variables

• First-order conditions

\[ F(D_t^a)U_C(\cdot; E) = \beta \gamma_t^a(E) \lambda_{A_{t+1}}(1 + \tau_t^C) \]

\[
\frac{U_L(\cdot; E)}{U_C(\cdot; E)} = (1 - \tau E_t^a)w_t \epsilon^a(E)H_t^a + \frac{1 - \tau_t^L}{1 + \tau_t^C} \frac{\partial b_t^a \alpha_R(L_t^a)}{\partial L_t^a} + \frac{\varphi_{P_{t+1}}^a}{1 + \tau_t^C} \frac{\partial \hat{R}_t^a(L_t^a)}{\partial L_t^a}
\]

\[ M_t^a = \left( \beta_D \theta_D \gamma_D \frac{-\varphi_{D_{t+1}}^{a+1}}{(1 + \tau_t^M) p_t^M} \right)^{\frac{1}{1-\gamma_D}} \]

• Education decision

\[ E(\xi) = \arg \max_{E \in E} J_{t-a_0}^{a_0}(X_{t-a_0}; E, \xi) \]
Equilibrium conditions

- **Input factors clearing**

\[
K_t = \sum_{a=0}^{\Omega} N_t^a \int_{\{\xi \in \Xi\}} A_t^a(\xi) \, d\Phi(\xi),
\]

\[
L_t = \sum_{a=0}^{\Omega} N_t^a \int_{\{\xi \in \Xi\}} \epsilon^a(E_t^a(\xi)) H_t^a(D_t^a(\xi)) L_t^a(\xi) \, d\Phi(\xi)
\]
Equilibrium conditions

• Input factors clearing

\[ K_t = \sum_{a=0}^{\Omega} N_t^a \int_{\{\xi \in \Xi\}} A^a_t(\xi) d\Phi(\xi), \]

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• Market goods clearing

Health goods: \[ M_t = \Gamma_H(1 - \ell_t)L_t, \]

Final goods: \[ C_t + G_t + K_{t+1} = K_t^{\alpha_K} (\Gamma_t \ell_t L_t)^{1-\alpha_K} + (1 - \delta)K_t \]
Equilibrium conditions

• Input factors clearing

\[ K_t = \sum_{a=0}^{\Omega} N_t^a \int_{\{\xi \in \Xi\}} A_t^a(\xi) \, d\Phi(\xi), \]

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Health goods: \( M_t = \Gamma_H(1 - \ell_t) L_t, \)

Final goods: \( C_t + G_t + K_{t+1} = K_t^{\alpha_K} (\Gamma_t \ell_t L_t)^{1-\alpha_K} + (1 - \delta) K_t \)

• Government

Social security: \( P_t = \sum_{a=0}^{\Omega} N_t^a \int_{\{\xi \in \Xi\}} b_t^a(\xi) \alpha_R(L_t^a(\xi)) \, d\Phi(\xi) \)

Public budget: \( 70\% P_t = \tau_t^S w_t L_t \) and
\( G_t + 30\% P_t = \tau_t^C C_t + \tau_t^L w_t L_t + \tau_t^R r_t K_t + \tau_t^M p_t^M M_t, \)
Computational strategy

- Given the initial endowments of each cohort $\xi = \{\theta_H, D_0, \phi_E\}$, we draw for every cohort a sample of size $n = 200$ from $\mathcal{U} ([0.02, 0.20] \times [0.031, 0.062] \times [2, 4])$. 
Computational strategy

• Given the initial endowments of each cohort \( \xi = \{ \theta_H, D_0, \phi_E \} \), we draw for every cohort a sample of size \( n = 200 \) from \( \mathcal{U} ([0.02, 0.20] \times [0.031, 0.062] \times [2, 4]) \)

• Given the population, the fertility rates and mortality rates by education \( \{ \gamma_t^a(E), f_t^a(E) \} \) \( E \in E, t = 1650, \ldots, 2350, a = 0, \ldots, 100 \)

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• Given the population, the fertility rates and mortality rates by education $\{\gamma^a_t(E), f^a_t(E)\}_{E \in E, t=1650, \ldots, 2350, a=0, \ldots, 100}$ see LE and TFR

• Given an exogenous productivity growth rate (Bergeaud, Cette, Lecat, 2016) and total public consumption $G_t$
Computational strategy

- Given the initial endowments of each cohort $\xi = \{\theta_H, D_0, \phi_E\}$, we draw for every cohort a sample of size $n = 200$ from $\mathcal{U}([0.02, 0.20] \times [0.031, 0.062] \times [2, 4])$

- Given the population, the fertility rates and mortality rates by education $\{\gamma_t^a(E), f_t^a(E)\}_{E \in E, t=1650, \ldots, 2350, a=0, \ldots, 100}$ see LE and TFR

- Given an exogenous productivity growth rate (Bergeaud, Cette, Lecat, 2016) and total public consumption $G_t$

Step 1  Start with an initial value for the co-state variables, prices, taxes, and contributions

Step 2  Calculate the household problem for all $\xi \in \Xi$ and cohorts

Step 3  Average all household profiles see profiles

Step 4  Multiply the average household profiles by the population

Step 5  Calculate the aggregate inputs and the total pension spending

Step 6  Adjust prices $\{r_t, w_t\}$ that close the capital and labor markets

Step 7  Calculate the new social contribution rates and tax rates that balanced the public budget

Step 8  Calculate $\text{Err} = \sqrt{\sum_{t=1650}^{2350} (r^{\text{supply}} - r^{\text{demand}})^2}$

Step 9  If $\text{Err} < 0.01$, then finish; otherwise go to Step 1
Figure 1: In-sample performance of the model: Benchmark
Policy analysis: Government

• **Benchmark** (*status quo*)

Social security: 
\[ P_t = \sum_{\alpha=0}^{\Omega} N_{\alpha}^t \int_{\{\xi \in \Xi\}} b_{t}(\xi) \alpha R(L_{t}^a(\xi)) d\Phi(\xi) \]

Public budget: 
\[ 70\% P_t = \tau_t^S w_t L_t \] and 
\[ G_t + 30\% P_t = \tau_t^C C_t + \tau_t^L w_t L_t + \tau_t^R r_t K_t + \tau_t^M p_t^M M_t, \]
Policy analysis: Government

- **Benchmark (status quo)**

  Social security: \( P_t = \sum_{a=0}^{\Omega} N_t^a \int_{\{\xi \in \Xi\}} b_t^a(\xi) \alpha_R(L_t^a(\xi)) d\Phi(\xi) \)

  Public budget: 70\% \( P_t = \tau_t^S w_t L_t \)

  \( G_t + 30\% P_t = \tau_t^C C_t + \tau_t^L w_t L_t + \tau_t^R r_t K_t + \tau_t^M p_t^M M_t, \)

- **SS contribution rate cap**

  Public budget:

  \[
  \begin{cases}
  \tau_t^S = \frac{70\% P_t}{w_t L_t}, & D_t = 0 \quad \text{if } \tau_t^S < 0.20, \\
  \tau_t^S = 0.20, & D_t = 70\% P_t - 0.20 w_t L_t \quad \text{otherwise,} \\
  \end{cases}
  \]

  \( G_t + 30\% P_t + D_t = \tau_t^C C_t + \tau_t^L w_t L_t + \tau_t^R r_t K_t + \tau_t^M p_t^M M_t, \)
Policy analysis: Government

- **Benchmark (status quo)**
  
  Social security: \( P_t = \sum_{a=0}^{n} N_t^a \int_{\xi \in \Xi} b_t^a(\xi) \alpha_R(L_t^a(\xi)) d\Phi(\xi) \)

  Public budget: \( 70\% P_t = \tau_t^S w_t L_t \) and 
  \( G_t + 30\% P_t = \tau_t^C C_t + \tau_t^L w_t L_t + \tau_t^R r_t K_t + \tau_t^M p_t^M M_t, \)

- **SS contribution rate cap**
  
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  \end{cases}
  \]
  
  \( G_t + 30\% P_t + D_t = \tau_t^C C_t + \tau_t^L w_t L_t + \tau_t^R r_t K_t + \tau_t^M p_t^M M_t, \)

- **Benefit reduction**: \( b_t^a(\xi) = f_{rep}(t - a) P_t^a(\xi) \)

  \[ f_{rep}(z) = \begin{cases} 
  0.80/(1 + \exp\{-0.50(z - 1890)\}) & \text{for } z \leq 1960, \\
  0.80 - 0.25 \frac{z-1960}{60} & \text{for } 1960 < z \leq 2020, \\
  0.55 & \text{for } z > 2020 
  \end{cases} \]
Figure 2: Internal rate of return of the Austrian pension system for cohorts born in 1980 and 2010: Case Benchmark (No diff LE)
Figure 2: Internal rate of return of the Austrian pension system for cohorts born in 1980 and 2010: Case SS contribution rate cap
Figure 2: Internal rate of return of the Austrian pension system for cohorts born in 1980 and 2010: Case **Benefits reduction**
Figure 3: Effective labor income tax rate for Austrian cohorts born in 1960, 1990 and 2020: Case Benchmark
Impact on labor: Effective labor income tax ($\tau E_{t}^a$)

Figure 3: Effective labor income tax rate for Austrian cohorts born in 1960, 1990 and 2020: Case SS contribution rate cap
Impact on labor: Effective labor income tax ($\tau E^a_t$)

**Figure 3:** Effective labor income tax rate for Austrian cohorts born in 1960, 1990 and 2020: Case **Benefits reduction**
Impact on labor: Effective labor income tax ($\tau E^a_t$)

Figure 3: Effective labor income tax rate for Austrian cohorts born in 1960, 1990 and 2020: Case Benefits reduction
Individuals delay retirement due to the reduction in benefits

Table 1: Average age at retirement in Austria, selected cohorts

<table>
<thead>
<tr>
<th>Cohort</th>
<th>Education</th>
<th>Benchmark</th>
<th>SS contribution rate cap</th>
<th>Benefits reduction</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>II-I</td>
</tr>
<tr>
<td>1960</td>
<td>Primary</td>
<td>58.8</td>
<td>58.8</td>
<td>58.8</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>High school</td>
<td>59.8</td>
<td>59.8</td>
<td>59.8</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>College</td>
<td>60.1</td>
<td>60.1</td>
<td>60.1</td>
<td>0.0</td>
</tr>
<tr>
<td>1990</td>
<td>Primary</td>
<td>62.2</td>
<td>62.2</td>
<td>62.8</td>
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</tr>
<tr>
<td></td>
<td>High school</td>
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<td>64.0</td>
<td>65.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>College</td>
<td>64.6</td>
<td>64.6</td>
<td>65.5</td>
<td>0.0</td>
</tr>
<tr>
<td>2020</td>
<td>Primary</td>
<td>62.0</td>
<td>62.1</td>
<td>63.5</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>High school</td>
<td>63.6</td>
<td>63.8</td>
<td>65.9</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>College</td>
<td>64.4</td>
<td>64.5</td>
<td>66.3</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Source: Model simulation
Growth: Impact of reforms on per capita income

Figure 4: Output per capita (productivity detrended), Austria 2000–2100
Conclusions

• Impact on the internal rate of return:
  - Individuals with higher education enjoy a greater internal rate of return from the pension system
  - The spread of the internal rate of return across educational groups becomes larger the greater is the difference in life expectancy
  - Lowering the pension replacement rate significantly reduces the internal rate of return of the pension system for all education groups

• Impact on the effective labor income tax:
  - How the pension system is financed does not substantially modify the effective labor income tax
  - In contrast, changes in the parametric components of the pension system has a stronger effect

• Impact on retirement: Reducing pension benefits increases the average retirement age
Pending work

- Minimum pension benefit
- Progressive labor income tax
- Firms
  - CES production function
  - Capital adjustment cost (Tobin’s q)
- Calibration (Bayesian)
Thank you!

This project has received funding from the Austrian National Bank (OeNB) under Grant no. 17647. We thank Stefani Rivic for collecting historical data for Austria.
Figure 5: Life cycle profiles for the cohort born in 1980: Case Benchmark
Internal rate of return (IRR): No Difference in Life Expectancy by Education

Figure 6: Internal rate of return of the Austrian pension system for cohorts born in 1980 and 2010: Case Benchmark Diff LE
Figure 6: Internal rate of return of the Austrian pension system for cohorts born in 1980 and 2010: Case SS contribution rate cap
Figure 6: Internal rate of return of the Austrian pension system for cohorts born in 1980 and 2010: Case **Benefits reduction**
Figure 7: Life expectancy and total fertility rates, Austria 1650–2350
**Table 2:** Coefficient of variation of the social security wealth at age 55 in Austria, selected cohorts (in %)

<table>
<thead>
<tr>
<th>Cohort</th>
<th>Education</th>
<th>Benchmark</th>
<th>SS contribution rate cap</th>
<th>Benefits reduction</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>II-I</td>
</tr>
<tr>
<td>1960</td>
<td>Primary</td>
<td>5.66</td>
<td>5.64</td>
<td>5.67</td>
<td>-0.02</td>
</tr>
<tr>
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<td>11.98</td>
<td>11.98</td>
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<td>College</td>
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<td>8.50</td>
<td>8.51</td>
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</tr>
<tr>
<td>1980</td>
<td>Primary</td>
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<td>3.61</td>
<td>3.44</td>
<td>-0.05</td>
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<tr>
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<td>12.52</td>
<td>12.65</td>
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<tr>
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<td>8.21</td>
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<td>-0.01</td>
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<tr>
<td>2000</td>
<td>Primary</td>
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<td>3.39</td>
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<tr>
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<td>High school</td>
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<td>12.67</td>
<td>12.94</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>College</td>
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<td>8.16</td>
<td>8.17</td>
<td>-0.02</td>
</tr>
<tr>
<td>2020</td>
<td>Primary</td>
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<td>3.61</td>
<td>2.33</td>
<td>-0.07</td>
</tr>
<tr>
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<td>High school</td>
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<td>12.58</td>
<td>12.78</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>College</td>
<td>8.13</td>
<td>8.22</td>
<td>8.27</td>
<td>0.09</td>
</tr>
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</table>
### Table 3: Tax rates and contribution rates in selected year, Austria

<table>
<thead>
<tr>
<th>Simulation</th>
<th>Year</th>
<th>Soc. Sec. contribution rate $\tau^S_t$</th>
<th>Consumption tax rate $\tau^C_t$</th>
<th>Labor income tax rate $\tau^L_t$</th>
<th>Capital income tax rate $\tau^R_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benchmark</strong></td>
<td>2020</td>
<td>0.197</td>
<td>0.174</td>
<td>0.223</td>
<td>0.131</td>
</tr>
<tr>
<td></td>
<td>2060</td>
<td>0.197</td>
<td>0.164</td>
<td>0.223</td>
<td>0.143</td>
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<tr>
<td></td>
<td>2100</td>
<td>0.266</td>
<td>0.164</td>
<td>0.240</td>
<td>0.166</td>
</tr>
<tr>
<td><strong>SS contribution rate cap</strong></td>
<td>2020</td>
<td>0.197</td>
<td>0.174</td>
<td>0.223</td>
<td>0.131</td>
</tr>
<tr>
<td></td>
<td>2060</td>
<td>0.199</td>
<td>0.164</td>
<td>0.224</td>
<td>0.143</td>
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<tr>
<td></td>
<td>2100</td>
<td>0.200</td>
<td>0.193</td>
<td>0.276</td>
<td>0.189</td>
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<tr>
<td><strong>Benefits reduction</strong></td>
<td>2020</td>
<td>0.197</td>
<td>0.174</td>
<td>0.223</td>
<td>0.132</td>
</tr>
<tr>
<td></td>
<td>2060</td>
<td>0.168</td>
<td>0.160</td>
<td>0.217</td>
<td>0.138</td>
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<tr>
<td></td>
<td>2100</td>
<td>0.176</td>
<td>0.152</td>
<td>0.219</td>
<td>0.157</td>
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</tbody>
</table>
Figure 8: Retirement ages, Austrian birth cohorts 1900–2050
• Instantaneous utility

\[
U(C, L; E) = \eta(E) \log \frac{C}{\eta(E)} - \phi E 1\{a < E\} - \alpha L \frac{L^{1+\sigma_L^{-1}}}{1 + \sigma_L^{-1}} + \alpha R(L) \nu_0 LE(E)^{\nu_1}
\]

• Capital net interest rate

\[
R^a_t(E) = \frac{(1 + r_t(1 - \tau^R_t))}{\gamma_t^a(E)}
\]

• Capitalization index of the pension system

\[
\hat{R}^a_t(L^a_t) = (1 - \alpha_R(L^a_t)) \cdot (1 + \hat{r}_t/\hat{\gamma}^a_t) + \alpha_R(L^a_t) \cdot 1
\]

• Rate of return to \(E\) years of education

\[
R^a_H = 1 + \left(\gamma_H / H_t^a\right) 1\{a < E\} \theta_H(H_t^a)^{\gamma_H} - \delta(D_t^a)
\]

• Effective labor income tax

\[
\tau^a_t = \left(\tau_t^C + \tau_t^L (1 - \tau_t^S) + \tau_t^S - \phi^P(Z) \varphi_{P, t+1}^a 1\{\omega_t^a(E) L_t^a > p_{py}\}\right) / (1 + \tau_t^C)
\]

• Effective human capital tax

\[
\tau^a_H = \tau_t^L (1 - \tau_t^S) + \tau_t^S - \phi^P(Z) \varphi_{P, t+1}^a 1\{\omega_t^a(E) L_t^a > p_{py}\}
\]